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IMPACT OF TECHNOLOGY ON SOCIETY

THOSE familiar with Mr. Lewis Mumford's earlier works will find little that is new in the six Bamford Lectures which, originally delivered at Columbia University, have now been published under the title "Art and Technics"*. Into this little volume, however, he has distilled the quintessence of that major undertaking to which he set his hand in "Technics and Civilisation" in 1934 and only completed last year in a fourth volume, "The Conduct of Life". In doing so, he has discarded the jargon and neo-dramatization of some of the larger books, and his thought and argument flow in sparkling manner, refreshing and stimulating. His theme, the manner in which man must come to terms with his environment, is expounded with a freshness and vivacity as if he had never handled it before; and, when he deals further shrewd blows against the weaknesses or abuses that he has already attacked, there is no hint of repetition or staleness in his words.

Readers of "The Culture of Cities" will recall, for example, Mr. Mumford's passionate plea in that volume for imaginative thinking about the whole purpose of design, and for a determined effort to think out and discover appropriate forms of expression for the new materials and powers now at our disposal. That forthright condemnation of our practice of clinging to obsolete methods and of attempting to force new material into the forms used for earlier products and other purposes is matched in this volume by two further attacks: in one, his lecture on "From Handicraft to Machine Art", Mr. Mumford castigates purposeless change in the machine; and in the other, when discussing symbols and function in architecture, he condemns the abuse of the doctrine that form follows function. The meaningless annual re-stylings of the less essential parts of a motor-car, he points out, largely nullify advances in technical efficiency which would enable manufacturers to lengthen the life and lower the cost of their models. Instead, he writes: ". . . You know that the canons of conspicuous waste, dear to the business man, and to the newly rich, have gotten the better of the canons of economy and function; and that somebody is picking your pocket of money you might use for better purposes, under the pretext that he is furnishing you with art. The current name for that particular perversion is industrial design".

That was worth saying, for waste of that order goes far beyond the production of styles in motor-cars. It might also be remarked that those in industry who have inclined to take a more conservative attitude, in agreement with the principle of stability which Mr. Mumford invokes, have sometimes been attacked for being unprogressive and withholding the advantages of technical and scientific advance. The position is, in fact, more complex than Mr. Mumford

* Art and Technics. By Lewis Mumford. Pp. v+162. (London: Oxford University Press, 1952.) 15s. net.

here indicates, and, while there is clearly room for the elimination of technological waste, the great merit of his criticism is the emphasis it places on the need for greater attention to the human factor in technological change. Apart altogether from the economic waste at present often incurred, the impact of technology on society requires fuller consideration from the point of view of the rate of innovation which mankind can endure, without detriment to human personality or the service of human needs as a whole.

In Mr. Mumford's own view, the greatest developments to be expected of technics in the future will consist in using machines on a human scale, directly under human control, to fulfil with more exquisite adaptation and with a higher refinement of skill the human needs that are to be served. He does not call for the rejection of the machine, but for its use to better purpose, so that it extends the rational and operative parts of the personality and does not wantonly trespass on areas that do not belong to it. "If you fall in love with a machine," he remarks, "there is something wrong with your love-life. If you worship a machine there is something wrong with your religion." A fuller degree of self-understanding and the restriction of the machine to its proper field would restore to life its freedom and creativeness.

This forthright challenge to the doctrine of 'faster, faster' and the assertion that, once the machine has achieved the power and economy of a good type, it should stand still at least until the creator again places himself above the level of his mechanical creature, is derived from Mr. Mumford's belief that the great problem of our time is to restore modern man's balance and wholeness. He believes that we must give man the capacity to command the machines he has created, instead of letting him become their helpless accomplice and passive victim; and we must bring back into the very heart of our culture a respect for the essential attributes of personality, its creativity and autonomy which Western man lost when he turned to the improvement of the machine. The great triumphs in music and painting of the nineteenth century, for example, depended not merely on the linking of art and technics but above all on the dominance of a belief in the creative human person. The new mechanical order of life made possible by the advance of technics should have released mind and energy for creative processes; but, in fact, it has impoverished our inner life because the machine so largely tends to replace the person and to subordinate his decisions to its mechanical needs.

Nor is this true simply of working hours. The impact on leisure hours has been no less stultifying, as a recent inquiry into the effect of television on social life and habits in Great Britain has indicated. Mr. Mumford's whole purpose in these lectures is to combat this mechanical environment and to restore order, value and purpose on the widest scale to human life. This means finding out how to make our subjective life more disciplined and resolute, endowed with more of the qualities that we have poured into the machine; and it means, also, as already indicated, instead of the pragmatic adaptation of human personality to the machine, a re-adaptation of the machine to the human personality. A human pattern, a human personality, a human tempo and a human goal must transform the activities and processes of technics, curbing them when they become dangerous to man's development and even suspending them until the appropriate political instruments and social institutions have been created.

In his attempt to formulate a working relationship between art and technics, as two essential sides of life, Mr. Mumford next challenges the belief that for the greater part of his existence man is concerned with improving the physical condition of his life, in particular his needs for food, clothing, shelter, security and physical care. The original great contribution of technics, he points out, was not merely to man's physical life, but also to his sanity and general balance. It also gave him a certain respect for the nature of the materials and processes with which he worked. Such respect did not come easily; but, from the beginning, a willingness to accept the hard facts and an understanding of the impersonal nature of things have been a condition of man's success both in dominating Nature and in coming to terms with himself.

Besides this, however, man's success in technics has been associated with a mechanical uniformity and repetitive order. This in itself tends to give man a sense of security, thus turning him towards technics and the object, just as his need for creative expression inclines him to art and the symbol. The problem of our time is that of restoring the appropriate balance between the two needs and tendencies—of establishing the dynamic equilibrium between art and technics, and between spontaneity and necessity, which has always marked the peaks in the development of any civilization. This problem, which is the very opposite of that which faced mankind at the end of the Middle Ages, demands for its solution the restoration of primacy to the human person, and the nurture of those aspects of human nature which have been repressed or displaced by mechanical developments.

Mr. Mumford does not make the mistake of prescribing a simple return to the handicraft processes of earlier centuries, though he considers that in the more advanced Western countries, even until the middle of the nineteenth century, handicraft itself was the mediating factor between pure art and pure technics. Leaving on one side the economic and social consequences of any such large-scale retreat from power production, even if it were practicable, the damage already done to the nature of man by mechanization is too widespread and deep-seated for handicraft alone to offer more than a very limited contribution. Any recent study of the use of leisure testifies to the loss of selectivity and of our powers of assimilation, as is noted by Mr. Mumford. To foster the personal discipline which he considers necessary for the restoration of effective control over the machine is no easy task and may well be a prolonged one.

Despite his skilful diagnosis, Mr. Mumford, like so many before him, is less satisfactory when it comes to prescribing the remedy. He adds little, if anything, to what he suggested in "The Conduct of Life". He sees clearly enough what is to be done; but there is little here to tell us how to do it. He recognizes the value of much that is already being done in industry to give new scope and importance to the workers as human beings. The studies being carried out by the British Institute of Management, the Acton Society Trust and the National Institute of Industrial Psychology are as much in line with the trend of his thought here, as are the earlier investigations of Elton Mayo, to which he refers specifically.

It would appear, however, that Mr. Mumford does not believe that the situation is hopeless, even if he presupposes the rejection of our gratuitous assumption that the existence of a mechanism for manifolding or mass production carries with it an obligation to use it to the fullest capacity. Mankind's mistake has been the reckless multiplication of such mechanisms without forethought as to the ultimate purpose to be served or the effects on man himself. Once this is recognized, claims Mr. Mumford, we achieve freedom.

To recognize and act on this view, however, demands a discipline that cannot itself be based on a new philosophy of freedom. To achieve the integration without which neither art nor technics can prosper is ultimately a matter of will. The recovery of wholeness and balance, and the regaining by man of his creativity and freedom, are essential if mankind is to contain the destructive forces that are now conspiring, almost automatically, to destroy.

Civilization in its present state, Mr. Mumford concludes, is not self-perpetuating. Nevertheless, though he gives no clear lead as to the way back to sanity and control, he is not without hope. Trends towards the renewal of life are indicated, and the ultimate objectives are defined. Nor are these essays on the theme of the impact of technology on society very different in spirit or approach from that of Lord Stamp—they insist that something more than a mere science of social adjustment is required. Like Lord Stamp, Mr. Mumford maintains unhesitatingly that behind all attempts to attune the pace of technological advance to the capacity of human beings for adjustment lies the belief in the value of human persons, and the conviction that failure to respect the human person, and the continued subordination of the individual to organization and to the machine, involves inevitably the downfall and destruction of civilization itself. While Mr. Mumford does not formulate the issue as a conflict of loyalties, like Herbert Read in his address on "Sign and Symbol" at the Present Question Conference last August, he insists quite as strongly that all turns on whether we continue to acquiesce in a civilization that proliferates anxiety in the mind and ugliness in street and factory, or whether we are willing to make the material sacrifice required for man to give expression to his creative nature and restore balance and harmony to life.

A CLASSIC OF PALÆO-ANTHROPOLOGY

Les hommes fossiles

Éléments de paléontologie humaine. Par Prof. Marcellin Boule et Prof. Henri V. Vallois. Quatrième édition. Pp. x+584. (Paris: Masson et Cie., 1952.) 4400 francs.

THE second and third editions of this now classic work on fossil man were separated by an interval of twenty-three years. The fact that a fourth edition has now appeared after a further interval of only six years is an indication of the important accessions to the subject which have been made in that short time—accessions which have in some instances strengthened, and in others modified, views previously widely held on human evolution. For example, the remarkably rich finds of the British–Kenya Miocene Expedition in East Africa include remains demonstrating that the Early Miocene anthropoid apes had not yet acquired some of the aberrant specializations of the modern apes, and they have thus now removed one of the main theoretical difficulties which have been raised against the conception of man's derivation from an anthropoid ape ancestry. The discoveries in South Africa by the late Dr. Robert Broom and his colleagues have brought to light a group of extinct hominoids approximating to the apes in the size of the brain but resembling *Homo* in numerous morphological and metrical details of the dentition, in many items of skull structure, and in characters of the pelvis associated with the erect posture. In this new edition these points are now emphasized, and the opinion is expressed that the South African fossils have narrowed to a very considerable extent the morphological hiatus between man and ape which appeared to exist before their discovery, and they also demonstrate that in the course of hominid evolution the expansion of the brain followed (rather than preceded) the adoption of an upright posture and gait. The discovery of further remains of pre-Mousterian man (for example, the Fontéchevade calvaria and the Quinzano occipital bone) confirms the implications of the Swanscombe cranial fragments and the Steinheim skull that the extreme varieties of Neanderthal man were actually preceded by a type of man more closely akin to *Homo sapiens*. On the other hand, the development by Dr. K. Oakley of the technique for estimating the fluorine content of fossil bones has led to the final rejection of great antiquity for the famous Galley Hill skull—a specimen which, because of its 'modern' character and supposed geological age, has led in the past to many speculations regarding the antiquity of *Homo sapiens*.

Marcellin Boule died ten years ago, and the new edition of "Les Hommes Fossiles" would perhaps be more accurately represented as his original book 'edited and revised' by Prof. H. V. Vallois. Prof. Vallois is an eminent authority on palæo-anthropology, and he has accomplished his task well, for he has preserved the individual character of Boule's masterly presentation of the subject of human evolution while at the same time giving adequate representation to those changing points of view which necessarily call for modification from time to time in any rapidly developing subject. There are, however, certain statements and conclusions which still find their place in this edition although it is doubtful if they could to-day withstand a critical analysis. For example, probably little reliance can be placed on the

inference as to intellectual functions drawn from the endocranial cast of the fossil skull found at La Chapelle-aux-Saints. The conclusions regarding the alleged simian characters of the foot in the Chancelade skeleton are difficult to accept in the absence of more detailed comparative studies (particularly if the evidence of a footprint of palæolithic man described by Dr. Casteret from a grotto in the Department of Herault is accepted as valid). The facet on the upper canine of the Talgai skull, which was at first taken to indicate an interlocking tooth of simian type, has been demonstrated by Prof. A. N. Burkitt to be nothing more than a facet of contact with the adjacent premolar tooth. The statement that the dingo in Australia was contemporaneous with *Nototherium* and *Diprotodon* is not based on really secure stratigraphical evidence. Finally, it may be suggested that the invention and use of group terms such as "les Préhominiens" and "les Présapiens" are bound to lead to confusion of thought, since they involve a certain misuse of taxonomic terminology. It has become abundantly clear during recent years that, in discussions on the evolutionary sequence of the Hominidæ, colloquial terms are to be avoided wherever possible, and only the scientific terms proper to taxonomy employed. The terms 'man' and 'human', for example, have come to assume, in popular usage, a very special connotation, and their rigid exclusion in discussions of the evolutionary origin of *Homo sapiens* would no doubt permit a much more objective approach to this problem and also avoid unfortunate misunderstandings.

I have referred above to "Les Hommes Fossiles" as a classic. Under Vallois's editorship it remains a classic—compendious in substance, clear in style, and judicious in its main conclusions. It is also beautifully illustrated.

W. E. Le Gros Clark

STRUCTURE OF POLLEN

Plant Morphology and Plant Taxonomy

Angiosperms (an Introduction to Palynology, 1). By G. Erdtman. Pp. xii+539. (Stockholm: Almquist and Wiksell; Waltham, Mass.: Chronica Botanica Co., 1952.) n.p.

THE term 'palynology' was coined in 1944 for the science of pollen grains and other spores, and this recent invention of a name indicates the increasing importance of the subject. Work in this field is proceeding in at least two directions. Pollen grains (and some other kinds of spores) are almost indestructible, so far as their external morphology is concerned, by the ordinary processes of decay as met with under natural conditions. Consequently, they are easily preserved as fossils in peat and other kinds of deposits. During the past two or three decades, the pollen content of peat has been intensively studied in Europe, North America and, to a less extent, in other continents. Spore content of older rocks is also receiving some attention. As a result, the structure of pollen and other spores of existing plants has had to be studied to provide standards for the nomenclature of fossil pollen. Angiosperm taxonomists have long recognized the value of pollen grain characters for classifying genera within certain families such as the Acanthaceæ. Recent researches prove that such characters can be used with advantage much more widely. The careful investigation by improved methods, combined with the examination of the pollen grains of many more species, genera and families, is providing new and extensive data for consideration by taxonomists.

Dr. G. Erdtman has rendered angiosperm taxonomists a great service in providing them with an up-to-date reference text-book to pollen structure. In this work the families of angiosperms are in alphabetical sequence—an arrangement that makes for easy reference and, for the time being probably wisely, avoids any commitments to a phylogenetic or other scheme of classification. There are excellent and numerous illustrations to illuminate the condensed descriptive text. The diversity of size, form, 'markings' and detailed structure of angiosperm pollen grains is extremely striking as one glances through these illustrations. It may be that a new descriptive terminology is unavoidable when a subject is studied extensively and intensively for the first time. One does, however, wonder if the invention of terms has not been carried to unnecessary extremes by some palynologists. In the glossary of this book more than two hundred terms are defined. The great majority of these have been proposed quite recently with direct reference to pollen morphology and are probably of only very specialized use.

The possibilities of pollen morphology throwing light on 'affinities' are evident in Dr. Erdtman's text. After the description of family pollen-grain characters, and diagnoses of special specific examples, valuable comparisons are made with the pollen grains of other families supposed by a previous author or authors to show relationships with the family under consideration. These comparative statements are matters of fact, not matters of speculation. They must in the future receive due attention in any attempt at a general classification of angiosperm families. In addition, there are significant suggestions that some widely accepted taxa are not homogeneous. It would be very valuable to have a classification of angiosperm families, sub-divided or amalgamated as considered necessary, based solely on pollen grain characters. Such a classification would, of course, be a special one serving limited, though important, purposes. With such a classification one could readily utilize pollen characters for improving a general classification and clearly see the taxonomic limits of palynology.

Taxonomists will look forward to further publications by Dr. Erdtman and to a general summary of the theoretical results of his painstaking researches.

W. B. Turrill

THE CIVIL SERVICE IN GREAT BRITAIN

The Fountains in Trafalgar Square

Some Reflections on the Civil Service. By C. K. Munro. Pp. x+202. (London: William Heinemann, Ltd., 1952.) 12*s*. 6*d*. net.

MR. C. K. MUNRO'S reflexions constitute a sensible, and possibly the most successful, exposition of the nature and mind of the Civil Service that we have yet been given. In a very readable book, which should appeal to the man of science though not especially addressed to him, writing under the name he used as a dramatist, Mr. Munro explains lucidly and easily, not simply the work and responsibilities of the Civil Service, and more especially of the administrative class of the Service, but even more of the outlook and mind of the Civil servant and the circumstances which determine his attitude to and

his habits of work. Even this can scarcely be called a popular book in the sense of one intended to reach that wider section of the public which most requires to have its misconceptions removed, and to be enlightened as to the close connexion between the activities the Civil Service is required to pursue and the services which that public demands of the State.

A recent B.B.C. inquiry into television has made it only too clear that the chances of reaching that section of the public by means of the printed word is slender. For those who do read his book, Mr. Munro should dispel a good many popular misunderstandings and remove the basis of some ill-informed and unfair jibes. Even more important, by his interpretation of the attitude of the Civil Service and explanation of the reasons behind its practice and procedure in handling such matters as complaints, planning, and the operation of controls, he goes far to promote the understanding and goodwill that are essential for the smooth functioning of government organization and the efficient service of the purposes of the State.

The success of this book is mainly due to the fact that, unlike so many other writers on the Civil Service, Mr. Munro confines himself to the one aim and does not allow himself to be beguiled into examining the problems which are being created for the Civil Service by the demands of a Welfare State. Nevertheless, he shows himself well aware of those problems, and he discusses with humanity as well as imagination such questions as those of controls and planning, the organization of government departments and their relations with Ministers.

Mr. Munro's very success induces the hope that, having explained so clearly the Civil Service as it is, he will now, in another book, discuss the ways in which the Civil Service could find answers to the new problems which are facing us all in the Welfare State and give us his view of the new public service which this new conception of the State requires. That hope is the more warranted because Mr. Munro displays to the full in this book the very qualities that can contribute most to bridging the gap between Civil servants and the community they serve, and to stimulating the circulation between the Civil Service and other professions which is now so desirable.

R. BRIGHTMAN

COMPARATIVE ANIMAL PHYSIOLOGY

Comparative Animal Physiology

By Prof. David W. Bishop, Prof. Frank A. Brown, Jr., Prof. Theodore L. Jahn, Prof. C. Ladd Prosser and Prof. Verner J. Wulff. Prof. C. Ladd Prosser, Editor. Pp. ix+888. (Philadelphia and London: W. B. Saunders Co., 1950.) 63*s*.

IN physiological research, difficulties of technique or of interpretation may sometimes be overcome by extending the investigation to include other methods or different species. It is natural that mammalian physiology should be studied intensively, but in fact the investigation of other forms has contributed greatly to the solution of many fundamental problems, and continues to do so. The advances recently made in the knowledge of nerve impulse transmission show how various methods can profitably be brought to bear on a problem.

In view of the outstanding intrinsic interest and possible wider complications of many aspects of non-mammalian physiology, it is surprising how few are the texts devoted to comparative animal physiology. This book provides a notable contribution in this field, and it should be of value to many classes of readers.

Prof. C. L. Prosser appropriately begins by stating his concept of the functions and aims of comparative physiology: "Comparative physiology treats of organ function in a wide range of groups of organisms. Comparative animal physiology integrates and co-ordinates functional relationships which transcend special groups of animals. It is concerned with the ways in which diverse organisms perform similar functions. Genetically dissimilar organisms may show striking similarities in characteristics and response to the same environmental stimulus. By the same token closely related animals frequently react very differently to their surroundings. While other branches of physiology use such variables as light, temperature, oxygen tension, and hormone balance, comparative physiology uses, in addition, species or animal type as a variable for each function. The generalisations which emerge from this experimental approach are important as biological principles which often aid in solving problems of cellular or special group physiology".

In presenting animal physiology from this point of view, the authors do not deal exhaustively with mammalian or cellular physiology, but these are included in enough detail to present an adequately balanced picture. The book is intended for advanced undergraduate or graduate needs, and to "introduce investigations to particular branches of the subject". In view of this, descriptive physiology of the various species is, of course, a prominent feature of the book, while ecological and evolutionary implications and biological generalizations are introduced at appropriate places, and emphasized at the end of chapters.

The whole book bears evidence of much thought and care, and the declared objectives are kept well in evidence throughout. The scope of this extensive text is very wide, so wide, in fact, as almost to defy a truly critical detailed appraisal by one person. The inclusion of so much material demands a concentrated type of exposition, which in this book is shown to be compatible with admirable clarity and precision. There are many excellent tables of quantitative data on various physiological and biological aspects of many kinds of animals; the variety and scope of these add appreciably to the value of the book. Throughout the text, attention is directed to numerous important questions in need of solution.

The bibliography is stated to be selective rather than comprehensive, and if occasionally an apparently important paper is not included, this fact must be remembered. Also, the student of mammalian physiology must be reminded that this branch is not intended to be stressed, although in fact most of mammalian physiology is very satisfactorily covered. The bibliography contains more than three thousand references.

The text is almost free from typographical error; on p. 121 of my review copy, however, part of the text seems to have been omitted.

The authors are to be congratulated on the ambitious conception of this book, its originality, wide scope and excellent balance. Their work has made easily accessible a mass of information useful to student and specialist alike, and the book should provide an added stimulus to the study of animal physiology on a comparative basis.

W. BURNS

Mind and Life

An Essay in Simplification. By A. G. Tansley. Pp. xi+172. (London: George Allen and Unwin, Ltd., 1952.) 15*s*. net.

THE author of this book is an ecologist who has previously written an exposition of psychology. He now presents this further volume, which he describes in a sub-title as "an essay in simplification". This is a discussion of various aspects of psychology, and its scope is shown by the chapter headings, some of which are: the structure of the mind; the energy of the mind; the functions and limitations of psychological concepts; instinct, heredity and environment; causation, determinism and free will; love and sex; the strength and weakness of psycho-analysis; the family and the community; the individual and the community; psychological reality and spiritual values; etc.

There is nothing new in this book—it is mainly a re-statement of the views of Freud, McDougall, Trotter and others. Its value, therefore, must lie in the clarity of exposition. This is very good, and the author does state clearly and intelligibly the theories which he describes. Mainly he accepts the Freudian point of view, and his descriptions of mental structure, and so on, are excellent. Not everyone would accept his views on free will, which he regards as possible within a limited sphere, since many would insist that every action is determined. He suspects the idea that the mother–child relationship is a sexual one, but admits (p. 103) that "it may, as in the Oedipus situation, run into the specifically sexual channel". This timidity is shown especially in his discussion on religion. Here he takes a leap into the dark and, abandoning any psychological basis, states (p. 106) that "The best evidence for the belief in spirit as the ultimate reality is derived from the phenomena of religious mysticism".

Those unacquainted with modern psychological theories will find the book of interest. It is well printed on non-shiny paper and is attractively bound in apple-green cloth. There is no index.

CLIFFORD ALLEN

Hydroponics

The Bengal System. By J. Sholto Douglas. Pp. xii+147+17 plates. (Bombay and London: Oxford University Press, 1951.) 10*s*. 6*d*. net.

THE growing of plants in sand, gravel or other inert medium with the aid of nutrient solutions has now become firmly established as a commercial method in many countries. In Great Britain its use has been confined, for obvious reasons, to the cultivation of glasshouse crops; but in other parts of the world, where shortage of water or unsuitable soil makes normal outdoor growing impossible or uneconomic, soilless cultivation holds out promise as a means of production, especially of food crops.

Mr. J. Sholto Douglas, an immensely enthusiastic amateur, became fired with the idea of using simplified techniques for food production in North India and, during some years of work in Bengal, produced results which, if not quite so startling as his enthusiasm might lead one to believe, were at least of great interest. He has embodied in this small book an account of the practical systems he developed, which are workable, so he claims, by Indian labour.

While he confines himself to this practical description of his own experiences, the book is interesting and useful. Unfortunately, he runs outside his brief and attempts in a short space to give an account of the underlying principles of plant nutrition in general and of soilless cultivation methods in particular. Here he is on unsafe ground and perpetrates some major errors of principle and fact. His lists of "suitable" solutions, for example, are entirely uncritical and in some cases absurd, while when he attempts to deal with certain unrelated scientific findings, such as colchicine treatment and the use of plant hormones, he goes entirely off the rails. If the book should see a second edition, it is to be hoped that the author will delete these irrelevant and unnecessary parts.

R. H. STOUGHTON

Exercises in Experimental Physics

Edited by N. C. B. Allen and Dr. L. H. Martin. Pp. xiii+237. (Melbourne: Melbourne University Press; London: Cambridge University Press, 1951.) 30*s*. net.

THIS book is specifically written to supplement the lecture courses in the second year of the B.Sc. in the University of Melbourne; but, of course, it could be used equally well by students of any university pursuing a similar course.

It is gratifying to know that the students at Melbourne are encouraged to read about the experiments before carrying them out, and to this end sufficient theory is given in the book to enable the experimenter to have an intelligent understanding of what he is about to do; in addition, references are made to suitable texts for further reading—a good feature.

The course is a very comprehensive one, if, as it seems, it is to cover one year of work only, and this latter fact probably explains the apparent lack of balance between subjects. For example, only four pages are devoted to the heat section, and a similar number to sound; presumably, courses for other years restore the correct balance. The work is thoroughly up to date in its approach and execution, and includes a section on the Geiger counter as well as work on radioactivity. The first chapter is devoted to an account of observations and statistical theory, which, it is hoped, students will thoroughly digest, and there is a useful appendix dealing with units.

Annual Review of Physical Chemistry

G. K. Rollefson (editor), R. E. Powell (associate editor). Vol. 3. Pp. x+416. (Stanford, Calif.: Annual Reviews, Inc., 1952.) 6 dollars.

WITH the publication of this, the third volume of the "Annual Review of Physical Chemistry", the venture begun under the capable editing of G. K. Rollefson and R. E. Powell in 1950 may be said safely to have passed the experimental stage. The general pattern is now clear: the articles can be divided broadly into two classes—the perennials, or annual reports proper, in which each year the progress over the year is given; and the special topics, varying from year to year, in which the reviewer is allowed to develop his subject more fully to cover a longer time period. The perennial review is perhaps the more difficult to do well, but some safeguard is provided by the policy which brings a new author to each subject annually.

Vol. 3 contains an essay on the quantum theory of valence (C. A. Coulson), topical reviews on polymeric electrolytes (P. Doty, G. Ehrlich) and on bond energies and distances (G. Glockler), a masterly summary of the theory of liquid solutions (G. Scatchard), a discussion on some aspects of photosynthesis (M. Calvin *et al.*), and fourteen other articles, in which virtually the whole field of physical chemistry is covered.

H. A. SKINNER

ROBERT HOOKE, 1635–1703

By Prof. E. N. da C. ANDRADE, F.R.S.

ROBERT HOOKE, one of the most inventive and far-seeing minds in the history of physical science, was born at Freshwater, in the Isle of Wight, on July 18, 1635, and so was some six years senior to Newton. He was a weakly child and, throughout his life, was afflicted by poor health. His diary for the years 1672–80, edited by H. W. Robinson and W. Adams (see *Nature*, 136, 358 ; 1935), is full of records of suffering and of the divers medicines which he took in the hopes of alleviating his distresses—catarrh, terrible headaches, vomiting, sleeplessness and fearful dreams. Chronic inflammation of the frontal sinuses was probably one of his troubles. If it is abundantly clear that he was often sharp-tempered and irritable, generally under provocation, it must be remembered that a night when he slept well was for him a matter worthy of special record.

He went to school at Westminster, one of the best schools in the country, at the time under the famous Dr. Busby, with whom he was in later life on very friendly terms. For example, he designed for his former headmaster the church at Willen in Buckinghamshire, which reminds us that Hooke was a rather more than competent architect, an example of his astonishing versatility. From Westminster he went to Oxford, where he had a chorister's place at Christ Church, which presumably implies that he had a good singing voice*. Oxford at that time, with such men as John Wallis, Seth Ward and John Wilkins, was a great centre of the new "Experimental Philosophy", the revolt against the authority of the ancients in matters of science which was soon to find its expression in the formal foundation of the Royal Society. Here Hooke became assistant to Robert Boyle, probably recommended in the first place to that wealthy and gentle young genius by his extraordinary manual skill. He made, for example, for Boyle the pump figured in "New Experiments Physico-Mechanical", 1660, which was the first air pump constructed in England and a great improvement on the earlier Guericke pump. In 1661, while still with Boyle, he published a little book dealing with capillary phenomena, which contains no capital discovery, but many acute observations and suggestions. In the following year he was appointed 'curator' by the newly-founded Royal Society, a poorly paid post with heavy duties. From then until 1682 his name and work were closely connected with the Society : he furnished it with abundant experimental demonstrations, with a variety of papers, some of them embodying original work of first importance, and, in general, did much to invigorate the Society and hold it together. His financial circumstances were much improved after the Great Fire of 1666 by the lucrative work which he carried out as City Surveyor, in which capacity he was chief assistant to Christopher Wren in the matter of rebuilding the City of London. Incidentally, Wren was one of the great men who were on very good terms with Hooke : Evelyn and Sydenham were others.

Hooke acted as secretary to the Royal Society from 1677 until 1682, and in the period 1679–82, when the *Transactions* were in abeyance, produced the *Philosophical Collections*, a record of scientific work at home and abroad. After giving up the secretaryship he still made frequent communications to the Society, until about 1696, when his health broke down completely. He died, after some wretched years, on March 3, 1703.

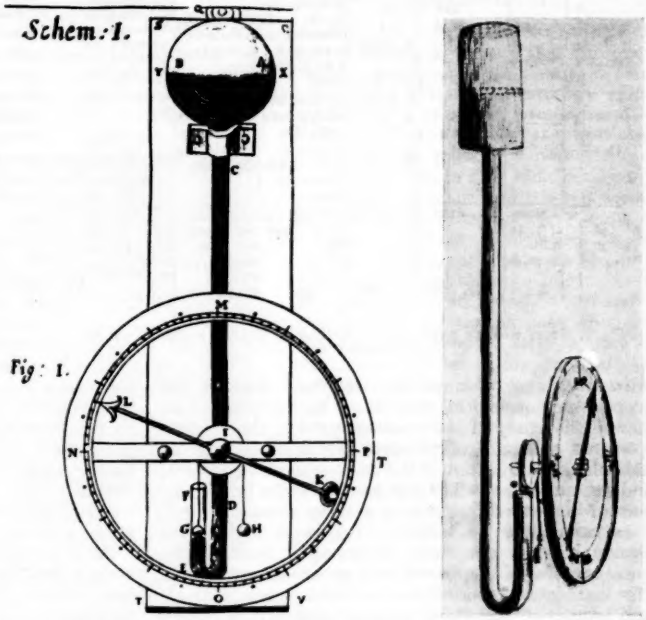

Fig. 1. Hooke's wheel barometer ; on the left is the diagram as given in the "Micrographia" ; on the right Hooke's original sketch, in the possession of the Royal Society*

Hooke's scientific work covers an astonishingly wide range and most of it bears the stamp of a powerful genius. If any single man deserves to be called the originator of the modern scientific instrument, it is Hooke. He invented all the meteorological instruments. His wheel barometer was long the standard instrument and can still be seen in use. He made a properly calibrated thermometer, with the freezing point of water as zero and a standard volume expansion. He invented the first hygrometer with an index, based upon the properties of the beard of the wild oat, and the first good wind gauge, as well as a self-measuring rain gauge. He also devised recording instruments, which worked, if but inter-

* It had occurred to me that possibly "a chorister's place" could be a surviving name for some kind of a sizarship, but Canon Jenkins, who is a great authority on the subject, assures me that the place does imply that Hooke had a good singing voice.

* Figs. 1, 2 and 3 are reproduced by courtesy of the Royal Society from the Wilkins Lecture delivered by Prof. E. N. da C. Andrade on December 15, 1949 (*Proc. Roy. Soc.*, A, 201, 439 ; 1950).

A SCHEME

At one View repreſenting to the Eye the Obſervations of the Weather for a Month.

Dayes of the Month and place of the Sun. Remarkable houſe.	Age and ſign of the Moon at Noon.	The Quarters of the Wind and its Strength.	The Degrees of Heat and Cold.	The Degrees of Dryneſs and Moyſture.	The Degrees of Preſſure.	The Faces or viſible appearances of the Sky.	The Notableſt Effects.	General Deductions to be made after the ſide is fitted with Obſervations: As,
4	27	W. 2.	9	2 5	29 4	Clear blew, but yellowiſh	A great dew.	From the laſt quarter the Moon to the change the weather was very temperate but cold for the ſeaſon; the Wind pretty conſtant between N. and W.
8			12	2 8		in the N. E.		
12	☌ 9. 46.		16			Clowded toward the S.	Thunder, far to the South.	
14 ☌ 4				2 9	29 5	Checker'd blew.	A very great Tide.	
12.46 8	Perigeū.		10					
12		W.SW. 1	7	2	29 5			
8		N.W.	9	2 8½	29 4	A clear Sky all day, but a little checker'd at 4. P.M. at Sunſet red and hazy.	Not by much ſo big a Tide as yeſterday. Thunder in the North.	A little before the laſt great Wind, and till the Wind roſe at its higheſt, the Quickſilver continued deſcending till it came very low; after which it began to reaſcend,
15 4	28		4	2 9				
☌ 6	☌ 24. 51.	N.	28					
13. 40 10			17	2 10	29			
10	N. Moon.	S.	110	1 10	28 5	Overcaſt and very lowring.	No dew upon the ground, but very much upon Marble ſtones, &c.	&c.
16 ☌ A.M.	at 7. 25'							
14. 37 ☊ 10. 8.								
	&c.	&c.	&c.	&c.	&c.	&c.		

Fig. 2. From Hooke's paper on "A Method of Making a History of the Weather"

mittently, and planned an excellent scheme for proper meteorological records. In particular, he viewed the study of the weather quite in the modern spirit, as a matter of physical law applied to solar radiation, the rotation of the earth and other factors, and was quite clear that the behaviour of the barometer was an important factor in foretelling storms.

In astronomy he invented telescopic sights and clearly pointed out their advantages, treating the question of resolving-power with great understanding. His instruments were furnished with screw controls and were of excellent design, embodying many pioneering features. He proposed, and published a figure of, the first clock-driven telescope. In connexion with his astronomical instruments he invented the universal, or Hooke's, joint.

In horology there seems to me little doubt that he invented the modern spring-controlled balance wheel, although there is a long history of dispute in this connexion. On the other hand, there seems to me insufficient evidence for ascribing to him the anchor escapement, with which he is usually credited.

He invented the efficient compound microscope and devoted particular attention to methods of illumination for microscopy, which enabled him to obtain the striking results illustrated in the plates to his renowned "Micrographia". With this microscope he made a number of fundamental discoveries in the biological field, such as the structure of a feather and the cellular structure of plants: he introduced the word 'cell' into biology. The impressive figures of the gnat, the flea and the louse show great observation and great precision and he carried out fundamental work on the life-cycle of the gnat. He was the first to propose immersion lenses, pointing out clearly their advantages. The "Micrographia" contains a great body of work in fields quite outside the microscopic world, to some of which reference is made elsewhere in this account.

Hooke has to his credit a large number of other instruments—the iris diaphragm, the refractometer for liquids, helioscopes, sounding machines and a device for bringing up samples of sea water from depths. It seems that he invented a multiplying and dividing machine. The spirit level which he made was not the first, but quite likely he had not heard of that of Thevenot, which anticipated his. His mind was so fertile, however, that it is not easy even to list the devices which he poured out, usually with only brief notes.

His contributions to scientific observation and thought form an equally impressive collection. In fundamental astronomy his services were completely overshadowed by Newton, but in 1674, before Newton had published anything on the subject, Hooke, with his extraordinary acuteness, had stated clearly that the problem of the planetary motions was one of simple dynamics, and that the closed orbits were due to gravitational forces deflecting the planets from the straight-line courses that they would otherwise pursue. A little later he put forward the inverse square law. He was, however, not sufficient of a mathematician to prove that this would lead to elliptic orbits, as Newton did; nor, of course, if he had been able to do this, had he the preternatural genius and application of Newton to develop the theme as Newton did. His speculations on the structure of the universe show his accustomed perception—"To me indeed the Universe seems to be vastly bigger than 'tis hitherto asserted by any writer". He was a brilliant observer: his astronomical observations alone would have secured his name a place in the history of science.

As a geologist he was a noteworthy pioneer, who clearly realized that fossils were a record of times past, and he treated the evolution of the globe in a modern spirit, in strong contrast to the fantasies prevailing in his time. It will perhaps suffice here to cite Sir Archibald Geikie, who speaks of his work in geology in the highest terms, referring in particular to "his remarkable powers of acute observation and sagacious reflection", terms which can be applied to all his work.

Hooke's work on combustion and respiration, if small in volume, was fundamental: with his usual perspicuity he realized the connexion between them and also the function of oxygen, although he did not further identify the gas than to say that it was copiously contained in saltpetre. He actually tried experiments with his own person on breathing at reduced pressure, enclosing himself in a tun surrounded by water.

Turning to physics, we have the familiar Hooke's law, demonstrated experimentally in a variety of ways; but that he also pointed out that, if the restoring force is proportional to the displacement, the vibrations must be isochronous, is less familiar. He treated crystal structure in a modern manner, building up crystal forms out of spheres. He was

clear as to the nature of heat: it was "nothing else but a very *brisk* and *vehement agitation* of the parts of the body", a conception which he amplified. In light he made striking observations on the colours of thin plates. His theory of light contains much that is strikingly novel for the time, but when he treats of colour he does not show his usual clarity. It is not usually known that he carried out fundamental experiments in sound, but he did so, inventing, for example, Savart's wheel some hundred and forty years before Savart.

Any short account of this kind dealing with Hooke's achievements tends to become a list, but this is almost inevitable. He did so much, and all of it was interesting, most of it astonishing for the date. He would take up a subject, work intensely at it for a short time—on occasion for a very short time—make an essential advance and then find his attention absorbed by some other subject. In character he was a complete contrast to Newton: whereas Newton would, as he said, keep the subject (usually one of fundamental significance) constantly before him until the first dawnings opened little by little into the full light, Hooke never concentrated on any one subject for long and the subject might be anything to which his attention had been drawn. Newton felt no need to communicate his discoveries and abhorred controversy of any kind: Hooke seems to have taken a lively pleasure in describing his latest advance and certainly did not shun the arena. Newton's was, of course, the greater mind, but Hooke was a very great man, of immense inventiveness and industry, the greatest experimental skill and rare intuition, who covered a prodigious range. As Lalande, considering his books, says: "Dans ces ouvrages on trouve les idées de la plupart de nos instruments modernes: c'était le Newton de la mécanique".

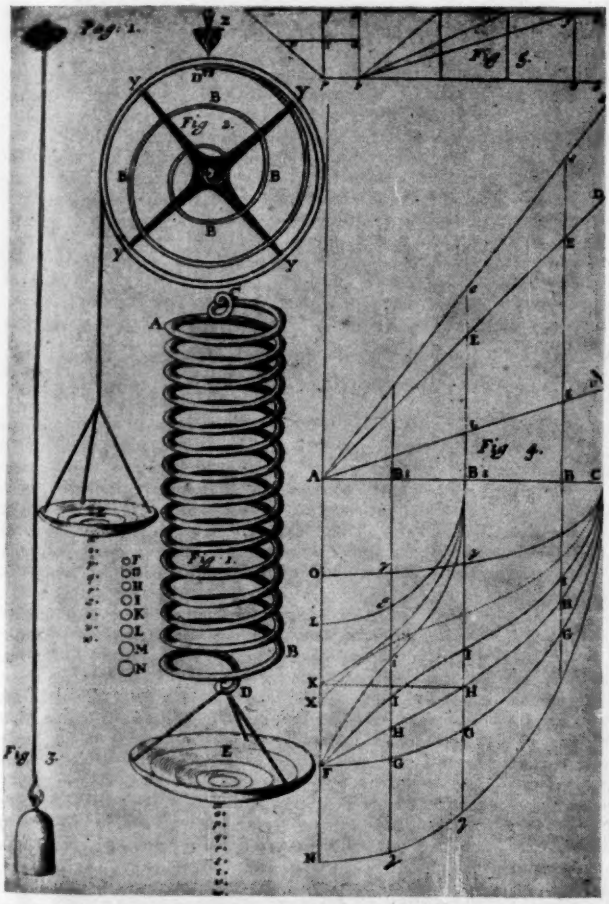

Fig. 3. The plate which illustrates Hooke's "Lectures de Potentia Restitutiva or of Spring"

HABITAT, VEGETATION AND MAN*

By Prof. W. H. PEARSALL, F.R.S.
University College, London

THOSE of us who have to deal with the out-of-the-way parts of Britain are aware that there are two problems which merit more consideration than they normally receive. These problems are those associated with production and with preservation.

It is still not generally appreciated that a large part of Great Britain, almost a third, is still biologically unproductive, supporting little but a deer or a sheep on thirty or forty acres of surface. One problem arises as to whether it is possible to raise the production of these areas to one more in keeping with our present economic position, for the day is past when we can afford to keep so large a part of our island in what is practically a sterile condition. Along with this problem there is a related one, of preserving for scientific study some of the remnants of the original native flora and fauna. This is one of the roles of the newly created Nature Conservancy—a function which could, no doubt, most easily be fulfilled by re-creating vanished units of vegetation and animal life on the less-valuable areas.

Both of these problems, however, involve a detailed knowledge of the natural trends of soil and vegetation in these islands and particularly in the unproductive areas. It is noteworthy that many of these wastelands, for example, the heaths of south-east England from Yorkshire south, are associated with the signs of occupation by early man, and it becomes pertinent then to ask whether they were always as inhospitable and unproductive as they may be to-day or whether they have changed since they were first occupied by man. Different sorts of evidence suggest that most of these areas were once forest-covered and that since man first occupied them their soils and general productivity must have greatly diminished. An area of particular interest is the Breckland in East Anglia. The pollen-analytical studies of Drs. Godwin

* Substance of a Friday Evening Discourse delivered at the Royal Institution on December 12.

and Tallantyre on mud-cores from Hockham Mere show clearly that this area was forest-covered for much of the post-glacial period. However, after the date of human occupation the area became deforested so that grass and herb pollen replaced that of trees. In addition, the appearance at this time of the pollen of plants such as *Plantago* and *Artemisia*, weeds of cultivation, suggests here, as elsewhere in Europe, that forest clearance was associated with human occupation. Similar evidence is available for Danish heaths, while deforestation of the heather moors in Yorkshire appears also to have taken place since the Bronze Age.

Apart from the debased condition of existing Breckland soils (which were described by Dr. A. S. Watt) there is, at present, no direct evidence of changes in soil conditions in this case; but results in the similar climate of eastern North America have given abundant evidence of the soil degeneration following deforestation, shown both by the lower nitrogen content which results and also in the greater soil erosion which has left its mark in the more inorganic character of recent lake sediments.

The study of lake sediments promises, indeed, to throw valuable light on post-glacial trends in soil conditions, for in many cases sediments of this type must be samples of the actual soil materials. The difficulty will be to allow for changes which take place in transit, or during and after deposition. Some evidence is already available from the English Lake District which poses the problems and suggests intriguing solutions.

In general, the post-glacial sediments in lakes like Windermere and Esthwaite Water appear to have been uniform in character during at least the first half of the post-glacial period or rather more. Later, and particularly during the past three thousand years, there are various types of change in the character of the sediments. If each of these changes were considered alone, several possible causes for each might be suggested, but if, as seems probable, all are connected one to the other, then all seem to run parallel to the onset and development of deforestation, and it remains for further inquiry to elucidate the connexions and to analyse the basal controlling influences.

Deforestation in the Lake District appears to have started in the second millennium B.C. Apparently it proceeded rapidly after the Norse occupations (say, from A.D. 1100 onwards) and reached a maximum in the sixteenth century. Following this, the lake muds corresponding in time show a minimum of organic matter which is attributed to soil erosion following deforestation. Parallel changes which apparently became intensified at this time include such features as a diminution in the electrical conductivity of the mud, and an increase in its acidity. The latter is particularly well shown in mud cores from the Esthwaite Fen, where it can be closely correlated with the diminishing base-saturation of the mud colloids.

The three features of the more recent mud-layers, decreased conductivity, decreased base-saturation and increased acidity, suggest that the soils from which the muds were derived may have suffered pronounced leaching in the course of time. The existence of rapid soil leaching under present-day climatic conditions was, of course, first demonstrated by Salisbury on various British dune systems and has since been shown elsewhere, especially by Hissink for Dutch 'polders'. The evidence from lake-muds apparently confirms the existence of this tendency in the past; it may also show that leaching proceeded at widely different rates at different times. If the present indications on this point are confirmed, leaching appears to have been extremely slow under the continuous forest-cover of the earlier half of the post-glacial period and to have been greatly accelerated as deforestation became more and more pronounced. There is, however, no evidence which serves to decide whether deforestation and soil deterioration in the Lake District were the results of 'natural' changes or of human action. The climatic deterioration known to have occurred just before the Christian era in north-west Europe may well have been a decisive factor in these changes, and it may be a matter of chance that its action should have coincided somewhat closely with the time of extending human settlements. Certainly one must be reluctant to ascribe the earliest deforestation of so many different parts of Britain to Neolithic man—until more is known of the numbers of individuals in each locality.

Any general conclusion which can be drawn from this type of work seems only to confirm the general impression reached by ecologists, that many types of 'marginal' land can only be really productive under forest. Undoubtedly much of northern Britain at least should never have been deforested, and it seems that the simplest biological method of re-creating lost fertility in such areas may be by afforestation. Further, these areas are now invariably of low nitrogen status and it seems to follow that alternative forms of land-use, if any exist, should properly aim towards products chemically different from the bread and beef of our lowland agriculture. A sound policy should aim first at the redevelopment of a more stable and productive soil status, and only later at high yields.

THE FIGHT AGAINST FILARIASIS IN THE PACIFIC

By Sir PHILIP MANSON-BAHR, C.M.G.

FILARIASIS remains the dominant scourge of the Pacific, especially in those islands mainly inhabited by Polynesians. These palm-covered coral-reefed atolls constitute what are popularly known as South Sea Islands and are made familiar to many in the film of the "Blue Lagoon" or by the vivid writings of Robert Louis Stevenson. There amidst fantastic and beautiful surroundings the filaria is rampant, finding conditions ideal for its propagation. Malaria, which in other parts of the tropics and indeed throughout Melanesia is the greatest bar to prosperity and progress, is here quite unknown. It is now more than seventy years since the transmission of the filaria (*Wuchereria bancrofti*) through the mosquito was proved by Sir Patrick Manson, and some forty years have elapsed since the Pacific filaria[1] was recognized as possibly a separate entity and its spread by a special distinct species of mosquito peculiar to the Pacific islands proved by me. Nevertheless, comparatively little had been done up to the present to transform these scientific facts into practice.

Filariasis and its maximal expression, elephantiasis, have existed in Polynesia for many centuries, and the disease appears to have been spread from one island

to another by migrating Polynesians during the fifteenth century. In the Central Pacific the area dominated by filariasis is enormous: an area delimited by long. 170° E. to 130° W. and lat. 10° N. to 24° S. in a vast oblong some 3,500 miles in length and 2,200 in breadth containing well over a thousand islands and a population of about 370,000 Polynesians.

In 1912 I was able to show that the chief vector of the non-periodic filaria in the Fiji Islands was the prevalent black-and-white striped mosquito which had been described by Theobald as *Stegomyia scutellaris* from specimens sent to him by F. P. Jepson[2]. This species has had a chequered career as regards terminology, being renamed *A. variegatus* and now finally *Aedes scutellaris pseudoscutellaris* by F. W. Edwards. The ecology and bionomics of the species have been thoroughly studied since by O'Connor[3], by Buxton and Hopkins[4], by R. W. Paine[5], and by Byrd, St. Amant and Bromberg[6].

Now the surprising discovery has been made by E. N. Marks[7] that, in what was thought to be a homologous species, two morphologically similar identities exist and that a new species, *Aedes scutellaris polynesiensis*, has to be recognized as valid, distinguished from *Aedes s. pseudoscutellaris* by the shape of the lobe of the coxite of the male. *Polynesiensis* is the most important and widespread species in that area of the Pacific now under consideration. This entomological problem is further complicated by the presence of a third, closely similar and related species of *Aedes* in Fiji, *Aedes scutellaris horrescens*, the female of which is indistinguishable from *pseudoscutellaris*, which was described by F. W. Edwards in 1935[8]. This is a forest-frequenting form and breeds in tree holes of coconut palms, tree ferns and other forest trees. The main distinction lies in the larvæ, which are readily separable as being more hairy.

The recent researches in Fiji by P. Manson-Bahr and W. J. Muggleton carried out in 1950 have now been published[9], supporting the arguments originally proposed in 1912 that the Pacific filaria should be considered as a separate species, for which the name *Wuchereria pacifica* has been proposed. From the work of J. J. C. Buckley[10] on the adult worms collected from Samoa and Fiji, it appears that some morphological differences can be recognized. In *W. pacifica* the head is oval in outline; in *W. bancrofti* it is round. The tail of the female lacks the bulbous swelling seen in *W. bancrofti*, and the length of the adult specimens, both male and female, is considerably smaller. Added to this, the non-periodic habit in the blood of the microfilaria of *W. pacifica* is adapted to the biting habits of its insect intermediaries *A. polynesiensis* and *A. pseudoscutellaris*. The fact that it does not develop normally in *Culex fatigans* or in *Aedes ægypti* reinforces the argument of distinct specificity. In contrast, the nocturnal microfilariæ of *W. bancrofti* are adapted to the night biting habits of *C. fatigans* and *Anopheles punctulatus farauti*, mosquitoes which act as the optimum intermediaries in Melanesia.

The geographical distribution of these two forms of filaria appears to be quite distinct, and *W. pacifica* is to be found in those Pacific Islands east of 170° E. It has been further suggested by me[11] that wherever *W. bancrofti* occurs it is the result of a domiciliary infection acquired during the night hours. Therefore, women and children are infected almost as heavily as the males, whereas in *W. pacifica* it is contracted in the daytime in the bush and plantations away from habitations and therefore this form of filariasis should be regarded as a rural infection. Men are consequently more heavily infected than women owing to their occupations in the open air in gardens and plantations. That the site of the infecting bites may also be important is shown by the frequency of elephantiasis of the arms in the Pacific as compared with British Guiana, where *W. bancrofti* is common and elephantiasis of the legs the rule. Repressive measures have to be based on these premises. In the nocturnal form the infecting mosquitoes must be attacked inside dwellings; in the non-periodic form in the immediate surroundings of dwellings and in the bush. The former (the nocturnal form), as has been shown by Giglioli[12] in British Guiana, is comparatively easy to eradicate.

Little repressive work against filariasis had been undertaken prior to 1942 in Fiji. In that year D. W. Amos[13], a retired business man who was an amateur entomologist, undertook an educational survey of the mosquito pest within the town of Suva. In 1943, appointed senior mosquito inspector, he commenced to train Fijian assistants in anti-mosquito measures and this scheme has since developed into the Mosquito Control Service. By these means the Fijians themselves have been made responsible in their villages and townships for the conduct of the anti-filariasis campaign. At the Central Institute in Suva Amos, and since Amos's death in 1949, Isimeli Rakai, his chief assistant, have trained classes of selected Fijian youths in this work, which comprises the structure and identification of the adult and larval stages of Fijian mosquitoes, and many other allied subjects. Up to 1948, more than 45,000 blood examinations had been made and an overall microfilaria rate of 18 per cent established. A training manual on mosquito control[14] by D. W. Amos was published in 1944 and revised in 1947. A shorter edition in the Fijian language and embellished with original cartoons was produced by Isimeli M. Rakai[15] in 1950.

There is no doubt that the Mosquito Service has done, and is doing, great work for Fiji, and the results of this campaign are already apparent. This was evident during my visit to Fiji in 1950. In the field, the Mosquito Service teams have been most active in clearing up the surroundings of villages, in filling in tree holes, burning coconut shells and debris, cutting down jungle, burying refuse heaps and generally making the village Fijians 'mosquito conscious'.

Now the battle has been joined by American workers in Tahiti and the preliminary results of their work have been published.

The anti-filariasis campaign in the Pacific has also received a great stimulus by the creation of the South Pacific Commission in 1949 and of which the first conference assembled in Suva in May 1950; afterwards a select group met in Tahiti during August 21–September 1, 1950, and a summary of the proceedings has been issued[16]. This was composed of delegates from French Oceania, New Zealand, Australia, Fiji, New Caledonia, Cook Islands, Samoa, Hawaii, University of California and other American interests.

Filariasis work in Tahiti is being conducted at the Institut de Récherches Médicales de l'Oceanie Française, Papeete, Tahiti. In July 1951, an annotated bibliography on filariasis, elephantiasis and related aspects in the South Pacific area was issued[17] by E.

Massal, executive officer, and D. J. Kerrest, research officer, Health Department of the South Pacific Commission.

Mosquito Control

In addition to the work in Fiji, medical officers in Samoa have been investigating methods of mosquito control in suppressing filariasis. In their paper, Jachowski and Otto[18] endeavoured to determine the maximum zone of infectivity in native villages by dissecting specimens of *Aedes pseudoscutellaris* (probably *A. polynesiensis*) at selected collecting stations situated at various measured distances from the living quarters. In doing so, they examined more than 2,300 specimens of *A. polynesiensis*. They were surprised to find that the highest incidence of filarial infection (in the thorax) was not in the immediate vicinity of the huts inhabited by the Samoans, as might well have been expected; but the 'index of transmission' was very high in the bush and garden trails 175–275 yards from the centre of all the villages investigated. The age and sex distribution of microfilaræmia in Samoans, added to the habits of the villagers, and the well-ascertained biting habits of the mosquito vectors, which coincide with the visits of the gardeners to their plots, all support the conception of the non-domestic transmission of this filariasis. In some details their findings differ somewhat from similar researches by Byrd, St. Amant and Bromberg some few years earlier (1945), when they found the highest rate of mosquito infection at a range of 25 yards from the village centre.

The merits of mosquito control and drug suppression combined and contrasted have been employed on the grandest scale so far in Tahiti, where Beye[19] and his colleagues have now issued their preliminary report upon the suppressive measures they have initiated for the control of filariasis, covering the period November 1948–September 1950. Their schemes were carefully planned and the total area was divided into nine divisions, including the adjacent island of Maiao. They, too, employed collecting stations for adult mosquitoes in order to determine their densities. There were no less than three 'resting' and an equal number of 'biting' stations in each selected area, where recordings were made two to three weeks prior to the establishment of control measures.

Next, the microfilariæ-rate per 20 c.mm. of blood had to be determined for each area, both before and after treatment with 'Hetrazan'. In order to obtain reliable data upon which to base their conclusions, measures varied in different areas, keeping as a control one with a microfilaria-rate of 38·6. In other areas different methods of suppression were instituted, some with 'Hetrazan' prophylaxis, others with sanitation and DDT. The effect of the several methods on the percentage of persons with microfilariæ was estimated at six and twelve months after the measures were commenced, and thus it was ascertained that a noticeable drop occurred in each of the four areas where 'Hetrazan' was administered, whereas wherever anti-mosquito measures were instituted there was a drop in the numbers naturally infected to 0·6 per cent.

'Hetrazan' Prophylaxis

Clinical work on 'Hetrazan' in human filariasis was initiated by Santiago-Stevenson and others[20] on twenty-six persons harbouring *W. bancrofti* in Puerto Rico. When it was given by the mouth, in doses of 0·5–2·0 mgm. per kgm. body-weight three times daily, the number of microfilariæ was greatly reduced by the second day and in some 34·6 per cent they disappeared entirely. Afterwards, work was continued in British Guiana[21] and on the Island of S. Croix[22], and again substantial reductions of microfilariæ were obtained which persisted for three to twelve months.

The exact dosage of 'Hetrazan' and the length of the course necessary to banish microfilariæ from the blood has not even yet been finally determined. I found[23] in Fiji that, if the deep venous blood is examined, although no microfilariæ may be present in the peripheral circulation, they can usually be demonstrated. This leads to a consideration of the mode of action of 'Hetrazan'. Hawking, Sewell and Thurston[24] have shown that microfilariæ (*W. bancrofti*) in enclosed cavities, such as the pleura, or in a hydrocele sac, are not affected by 'Hetrazan'; but that, after treatment, they congregate in the liver, where they are attacked and devoured by leucocytes. It appears probable that 'Hetrazan' modifies the microfilariæ in some manner so that the leucocytes are attracted to them as if by some opsonizing effect.

It would seem that a very considerable reduction in numbers results from comparatively small doses of 'Hetrazan', but that larger ones are more lasting. Halawani[25] in Egypt treated ambulant cases (*W. bancrofti*) with 'Hetrazan' in doses of 0·9–2 mgm. per kgm. three times daily. In Indian nocturnal filariasis (*W. bancrofti*), Raman and colleagues[26] gave 0·45–2·2 mgm. per kgm. similarly for twenty-one days with a similar result. In East Africa, Laurie and associates[27] have given 'Hetrazan citrate' in doses as high as 12 mgm. per kgm. every twelve hours for three days to banish microfilariæ from the blood. Nine moderately infected patients received a single dose of 20 mgm. per kgm., and it was found that microfilariæ were absent from the blood two years later; but it is laid down that those patients with greater numbers of microfilariæ are definitely more difficult to sterilize than those with smaller numbers.

The most detailed account so far of the control of filariasis with 'Hetrazan' has been published by McGregor, Hawking and Dean Smith[28] at the Medical Research Council's Field Station in the Gambia. The dosage of 'Hetrazan citrate' was 25 mgm. per kgm. daily for five days. Of 154 infected persons who completed the prescribed course, 64 per cent had their blood free from microfilariæ so long as ten months later. In the remainder who did not respond so satisfactorily the parasitæmia was substantially reduced.

It is not surprising to learn that these large doses were not well tolerated and toxic effects appeared in one quarter. This form of medication soon became unpopular and it was only with great difficulty that the trial was completed.

In non-periodic Pacific filariasis, the microfilariæ are possibly more difficult to exterminate. In addition to the work of Beye and colleagues in Tahiti, Gaillard and Mille[29] gave small doses—2 mgm. per kgm. three times daily for seven days—and microfilariæ were banished in 87 per cent for about four months. It is still open to question whether one large loading dose is more effective in reducing microfilaræmia than a more prolonged course of smaller ones.

It would thus seem probable that the disproportion of the severer manifestations in the two forms of filariasis, nocturnal and non-periodic, discussed in this article reinforces the argument that, in

the former (*W. bancrofti*) infections and in the latter (*W. pacifica*), we are dealing with separate entities which necessitate different methods of prophylaxis and possibly of treatment as well. (The statement made by McGregor and colleagues that out of 603 Gambians examined there were only six with signs of filarial disease and that the people regard it as altogether of minor importance must also be borne in mind.)

Owing to the uncertainty of the dosage and length of treatment with 'Hetrazan' in order to banish microfilariæ from the peripheral blood for a sufficient time to render mass application a practical proposition, added to the almost insuperable difficulties which arise in carrying through such a programme in Polynesians, there exists at present a prejudice against this form of causal prophylaxis. The minimal infective microfilarial concentration in the blood (after 'Hetrazan' treatment) for *A. pseudoscutellaris* and *A. polynesiensis* has yet to be determined. According to my observations[23] it is about four microfilariæ per 20 c.mm. of blood.

It appears probable that 'species sanitation' against the main vector, as had been practised in Fiji and Rarotonga, and now in Tahiti, promises to be the most effective measure in the ultimate eradication of Pacific filariasis, and that the actual carrying out of repressive measures should be left to specially trained teams of Polynesians.

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OBITUARIES

Dr. C. S. Hudson

THE death occurred suddenly on December 27, 1952, of Dr. C. S. Hudson at the age of seventy-one, and carbohydrate chemists all over the world mourn the passing of one of their greatest leaders.

Claude Silbert Hudson was born in Atlanta, Georgia, and spent a happy boyhood in Mobile. He entered Princeton University in 1897 in order to study for the Presbyterian ministry. He became so interested in chemistry during his course for the B.S. degree that eventually he decided to become a scientist. After graduation (1901) he was elected into an endowed fellowship in experimental science at Princeton and began an investigation on the mutarotation of milk sugar, under W. F. Magie, then professor of physics. This first investigation, published in 1902 when he was twenty-one, marks the beginning of his brilliant series of more than two hundred and fifty publications on the carbohydrate group.

Hudson's first leanings were towards the physical side of chemistry, and he spent a profitable year with Nernst at Göttingen (1902–3). On returning to the United States he became a research assistant to A. A. Noyes in Boston, and then he held an instructorship in physics at Princeton (1904–5) and at Illinois University (1905–7); after holding several other posts he was appointed chemist to the Bureau of Chemistry at Washington, where he stayed until 1919. He then became a consultant chemist for four years, afterwards joining Frederick J. Bates at the National Bureau of Standards, where he carried out many notable researches up to 1929. In this year he was invited to the professorship of chemistry in the U.S. Public Health Service, where he remained until his retirement at the age of seventy. During his tenure of this latter post he was enabled to secure the assistance of a succession of brilliant young scientists who, inspired by his able leadership, have achieved world-wide distinction.

Among his many great works on carbohydrates, Hudson's contributions to preparative methods and to the relationship between rotatory power and structure stand out, while his famous 'lactone rule' was perhaps his greatest single personal contribution and was one of the most notable landmarks in carbohydrate chemistry. He was a brilliant experimentalist and his writings bear the stamp of a master mind. He infused his passion for the sugars into his many pupils, who bore him great respect and devotion.

In the late 1920's he engaged in a notable controversy with the late Sir Norman Haworth regarding the ring structure of certain of the sugars, and following his eventual acknowledgment of the correctness of Haworth's views the two began a friendship which both greatly treasured. The results of this friendship were seen in the founding of the "Advances in Carbohydrate Chemistry", to which Hudson as the senior editor particularly devoted the last few years of his life and from the guidance of which he will, indeed, be sadly missed. He was largely instrumental also for founding the "Starch Round Table", which provides an annual forum for discussions on this important foodstuff.

Many honours came to him, particularly from the American Chemical Society. He received the Borden Medal and Award (1941), the Nichols Medal of the

New York Section (1916), the Willard Gibbs Medal of the Chicago Section (1929), the Richards Medal of the North-Eastern Section (1940) and the Hillebrand Prize of the Washington Section in 1931, etc. He was a member of the National Academy of Sciences, and the Chemical Society in London elected him to honorary fellowship. He received the major share of the Sugar Research Foundation Grand Award in 1950.

Hudson loved life and lived it to the full. He was a delightful companion with an inexhaustible fund of 'true' stories, and he engaged the affection of all who knew and admired his wisdom. He is survived by his wife (Erin Gilmer) and by two married daughters.

M. Stacey

Prof. C. J. Hawkes, O.B.E.

Charles John Hawkes commenced his professional career in the engine rooms of the Navy, and from there, in 1912, he became joint secretary of the Royal Commission on Fuel and Engines under the chairmanship of Admiral of the Fleet Lord Fisher. Thenceforward, Commander Hawkes was in the forefront of naval research at a crucial period in naval history, and as the first superintendent of the Admiralty Engineering Laboratory he did much to develop the heavy-oil engine for submarines.

His reputation as a leading authority on the heavy-oil engine accompanied him when, in 1920, he was appointed professor of mechanical, marine and civil engineering in the University of Durham. His work at King's College, Newcastle upon Tyne, was paralleled by his zealous participation in the activities of the North East Coast Institution of Engineers and Shipbuilders. Of this important body he eventually became president, gold medallist and honorary fellow, and his papers, including the fourth Andrew Laing Lecture, were outstanding contributions to the Institution's *Transactions*. Prof. Hawkes's work was well known abroad and his knowledge of his subject won the regard of many engineering bodies. He was elected an honorary member of the American Society of Naval Architects and Marine Engineers, and, in 1938, had the unusual experience of making an after-dinner speech by radio on the occasion of the Society's annual dinner in New York. His research was not confined to heavy-oil engines. In Newcastle upon Tyne he inspired and superintended university research and served on the Heat Engines Trial Committee of the Institution of Civil Engineers, of which he was a full member. Insistent always on the importance of practical training as a basis for academic studies, he underlined this belief by distinguished work on the Board of Trade Departmental Committee on Marine Engineers' Certificates, for which service he was awarded the O.B.E.

To the younger generation of engineers and to his university colleagues in Newcastle upon Tyne, Hawkes will be remembered for his buoyant and witty spirit, and for his sincere interest in the good of his students and mechanics. He was always approachable and was as much at home, and greeted with as much affection, in the workshops as in the lecture theatre. His rich store of naval anecdotes, through many of which he recalled his work under Admiral Fisher, are still remembered along Tyneside. Though coming relatively late to university work, he did much on Faculty and Senate to raise standards, and it fell largely to his credit that Armstrong College was well known as a centre of progressive engineering education. Prof. Hawkes helped to carry the College through to its new status of King's College, and it was for his valuable work over a period of twenty-six years that the University of Durham conferred on him the title of emeritus professor, and the honorary degree of doctor of science. His death on January 30 at the age of seventy-two represents a loss to his many friends on Tyneside, and to the related spheres of engineering and education.

W. Fisher Cassie

Prof. Nathan Banks

Prof. Nathan Banks, emeritus curator of insects in the Museum of Comparative Zoology, Harvard University, died on January 24 at the age of eighty-four. Prof. Banks was born at Roslyn, N.Y., on April 13, 1868. He received a B.S. degree from Cornell University in 1889 and an M.S. from the same University in 1890. He was employed by the Division of Entomology, U.S. Department of Agriculture, during 1890–1916. In 1916 he was appointed curator of insects in the Museum of Comparative Zoology, Harvard University, a post which he held until 1944. Banks was one of the best-known entomologists of his time. He published extensively on Neuroptera and other orders of insects and also on spiders, and he built up and maintained in the Museum of Comparative Zoology at Harvard one of the finest collections of insects in America. He is noted also for his bibliographical work on the literature of insects. We, his associates at the Museum of Comparative Zoology, feel his loss very deeply.

P. J. Darlington, jun.

Mr. Rhys Jenkins

With the death at Hastings on January 27 of Rhys Jenkins, the engineering world loses its oldest and its foremost historian. Born so long ago as September 29, 1859, in the village of Mountain Ash, Glamorganshire, Jenkins served an apprenticeship in the engineering works of Richard Nevill at Llanelly and then was a draughtsman in well-known works in Leeds, Grantham and Gainsborough; in 1884 he joined the examining staff of the Patent Office, from which he retired as a senior examiner in 1920 after thirty-six years service. He had joined the Institution of Mechanical Engineers in 1880 and had therefore been a member for more than seventy years.

Immersed as he was at the Patent Office in the history of inventions, he devoted his leisure to the systematic study of a great variety of industries, visiting many localities, collating material from manuscripts, local histories, State records and the like, and thus amassed a wealth of information which was critically examined and arranged. His first work of note was his book "Power Locomotion on the Highway" (1896), followed six years later by his "Application of Mechanical Power to Road Vehicles" — a mine of information for researchers. These were followed by a succession of historical surveys published in the technical press and various journals.

With other engineers and students of engineering history, he attended the Watt centenary celebrations at Birmingham in 1919, and on the formation next year of the Newcomen Society for furthering the study of the history of engineering and technology, became one of its most active members and served as president during 1924–25. He enriched its *Transactions* with paper after paper, dealing with such

matters as the iron industry, the steam engine, fire engines, the work of Savery, Newcomen, Jonathan Hornblower, Arthur Wolff, and others. At nearly every summer meeting of the Society in its earlier days he was able to review the industries of the district visited. A major work was his "James Watt and the Steam Engine" (1927), written in collaboration with the late Dr. H. W. Dickinson. The esteem with which he was held by his fellow members was shown by the re-publication by the Council in 1936 of his miscellaneous papers which had appeared before 1920. E. C. SMITH

WE regret to announce the following deaths:

Father A. Gatterer, *S.J.*, director of the Astrophysical Laboratory, Specola Vaticana, Castel Gandolfo, on February 17, aged sixty-seven.

Prof. Justin Jolly, professor of histophysiology in the Collège de France and *académicien libre* of the Paris Academy of Sciences, on February 1, aged eighty-two.

Prof. N. A. V. Piercy, professor of aeronautical engineering in the University of London (Queen Mary College), on February 1, aged sixty-one.

NEWS and VIEWS

Botany at Oxford:

Prof. T. G. B. Osborn

PROF. T. G. B. OSBORN, who has been Sherardian professor of botany in the University of Oxford since 1937, is retiring from that chair. He went to Oxford from the University of Sydney, Australia, where his researches in the ecology of natural and semi-natural vegetation laid a firm foundation for later work. Under his guidance the Department of Botany remained happy during a period when botany in Oxford was expanding in the cramped surroundings of the old building. It was owing to his initiative that the Department moved to the new laboratory in the Museum, and there close co-operation with the Botanic Gardens, first begun by him, is still maintained. Indeed the great improvements in the Gardens which have occurred in recent years owe much to his expert supervision and advice. Prof. Osborn has been active in University business and, especially during the War, in advisory work for the Agricultural Research Council and other public bodies. These calls upon his time and especially those associated with the design of the new laboratory were so great that his own researches inevitably suffered. The solid achievement of causing the new laboratory to be built will be found, perhaps, to be a greater contribution to botany than any series of laboratory experiments. Oxford will regret the departure of a professor who has advised and guided his colleagues with tact and forbearance.

Prof. C. D. Darlington, F.R.S.

PROF. C. D. DARLINGTON, who is to succeed Prof. T. G. B. Osborn, was born in 1903 and educated at St. Paul's School and Wye College. On graduating he joined the staff of the John Innes Horticultural Institution, of which William Bateson was then director. A year or so earlier Bateson had returned from a visit to the United States, where he had seen evidence which convinced him that the proper study of genetics required also study of the chromosomes. He then appointed W. C. F. Newton to his staff as a cytologist, and when Darlington went to the Institution he also joined in this new line of work. Newton's early death in 1927 put an end to their collaboration and left Darlington to continue, at first virtually alone. Soon aided, however, by a growing body of research students he then began that remarkable series of advances which turned cytology from a descriptive into an analytical study, with its own principles, and taking its place as an essential part of the greater structure of genetical science. The new cytology was expounded in the now famous "Recent Advances in Cytology", and it reached its zenith with the smaller though no less important book "The Evolution of Genetic Systems", which discussed and presented the chromosome mechanism, in all its great variety of forms, as the product of evolution by natural selection.

During this period Darlington had been appointed first head of the Cytology Department and later, when Sir Daniel Hall retired in 1939, director of the 'John Innes'. He saw the Institution through the difficult period of the War, during which the old buildings at Merton suffered serious damage, and then through its removal to a new and very much larger home at Bayfordbury. He was elected to the Royal Society in 1941 and received a Royal Medal in 1946. At the same time his interests extended to cover genetics as an even wider discipline, well exemplified by his writings on cytoplasmic heredity, viruses and cancer which he presented as part of the broader picture in which heredity, development and infection were all joined together for the first time. Prof. Darlington takes a wide knowledge and understanding of plants, horticultural as well as botanical, to his new appointment at Oxford, which will provide opportunity for presenting, in a broader field, genetical science as the firm base from which so much in modern biology can be seen to spring.

Society for Visiting Scientists

Prof. A. V. Hill and Sir Harold Spencer Jones, president and past-president respectively of the Society for Visiting Scientists, have issued an appeal for funds to enable the Society not only to extend but even to maintain its activities. In 1944, when many Allied scientists were working in Britain, the Society was established in London, on the initiative of the British Council and in consultation with the Royal Society, as a centre where overseas and British scientists could meet. The Society has expanded rapidly; it has become widely known abroad, and considerable goodwill towards science in Britain has been built up and fostered through its 1,730 overseas members—a number which is constantly increasing. It enjoys the esteem and encouragement of organized international science, as represented by Unesco and the International Scientific Unions, as well as of Government science in Britain and of many learned societies. It is on friendly and co-operative terms with the scientific liaison officers of the Commonwealth countries and with the science representatives of other countries. At the Society's House, there is at the disposal of scientific institutions and of individual scientists a body of information about science and scientists not easily available elsewhere, and this is drawn on by many at home and overseas. The

Overseas Science Students Association, formed in 1952 to welcome postgraduate science students from other countries and to bring them into closer contact with each other and with the scientific life of Britain, has its home in the premises of the Society for Visiting Scientists. The Society's financial resources were hitherto derived mainly from an annual grant of £4,000 from the British Council. The recent reduction in the Government's grant to the British Council as a whole has forced the Council to halve its annual grant to the Society. To enable the Society to function efficiently, at least £6,000 per annum is required; it is therefore necessary to raise an annual sum of £4,000. It is hoped that much of this sum will be contributed by corporations and individuals through deeds of covenant, though other subscriptions will, of course, be welcomed. Inquiries should be sent to the Honorary Treasurer, Society for Visiting Scientists, 5 Old Burlington Street, London, W.1.

Flamsteed's Observatory

Treasury approval has been given to a scheme, proposed initially by the Astronomer Royal, under which the historic buildings of the Royal Observatory at Greenwich will be taken over, as they are vacated by the removal of the Observatory to Herstmonceux, by the National Maritime Museum. These include the original building, designed by Sir Christopher Wren, and built in 1675, containing the Octagon Room (the observatory of the first Astronomer Royal, the Rev. John Flamsteed), and the various additions made during the eighteenth century. The historic instruments, which have played so large a part in the progress of fundamental astronomy, will remain at Greenwich. They include Halley's transit instrument—the first transit instrument to be used in England; the zenith sector, with which Bradley discovered the aberration of light and the nutation of the earth's axis; and the Airy transit circle, installed in 1851, which by international agreement defines the zero of longitude. It is the intention of the director of the National Maritime Museum to move a portion of the exhibits relating to navigation from the main museum to the Observatory, which will become an Annexe of Astronomy and Navigation. This is peculiarly appropriate, as the Royal Observatory at Greenwich was established by Charles II in the interests of navigation. The Wren building, which suffered damage during the War, has been repaired by the Ministry of Works and restored as nearly as possible to its original appearance. It is expected that the Octagon Room will be opened to the public about the beginning of May. The Shepherd 24-hr. electric clock, outside the main gate, which is an object of interest to visitors, will remain in position. The custom of dropping the time-ball at 13.00 hr. each day has been resumed: the time-ball was installed in 1833 and provided the first public time-signal in Great Britain.

Agriculture in the United States

During the years 1945–50 Mr. A. N. Duckham, then agricultural attaché to the British Embassy in Washington, travelled all over the United States, gaining an insight into the methods of farming in each of the forty-eight States he visited. An interesting account of his experiences is given in an illustrated booklet entitled "American Agriculture: its Background and its Lessons" (pp. 78+4 pl.; London: H.M.S.O., 1952; 2*s*. 6*d*. net). The chief objects of this report are to provide the necessary technical and commercial background for a proper understanding of farming methods in the United States, and to point out features of their agriculture which may hold positive (or negative) lessons of potential value to the British farmer. The subject is dealt with from four main aspects—geographical and social background; rural organization and agricultural services; production techniques; and farm organization and labour economy—while maps and statistics giving crop acreages and yields, number of livestock and machines, etc., are included in an appendix. Throughout the report it is abundantly clear how differences in soils and climate, natural resources, land-tenure systems and social background have influenced the development of agriculture in the two countries of Great Britain and the United States, and that in general no direct comparison can be made between their farming practices. Nevertheless, Mr. Duckham appears to regard the human element as the chief cause for present-day differences, the British farmer taking a special pride in good husbandry, whereas his American counterpart attaches more weight to efficient organization and labour economy. Each, he maintains, has something to learn from the other, and, if this were achieved, rural standards on both sides of the Atlantic would be raised.

Rabbit Problem in Gotland Island

In Bulletin No. 9 of the Royal School of Forestry, Stockholm (Stockholm: Kungl. Skogshögskolan, 1952; 5 kr.), G. Notini and S. Forselius discuss the methods which have been undertaken to exterminate the wild rabbits on Gotland Island. The wild rabbit was introduced into Sweden with the object of providing a new game animal of commercial value. Vigorous stock was selected and care was taken to ensure the proper environmental conditions, based on European accumulated experience in parts where the stock had become more or less stabilized, excess numbers being kept down by small predatory animals and also disease. As has occurred in other parts of the world where mammals, birds and plants have been introduced outside their own habitat, the rabbits in Gotland increased rapidly in numbers. None of their ordinary checks was present, the only one being the occasional severe winters experienced in the island. The ordinary methods of man—shooting, poisoning, snaring, etc.—but not poison, have proved ineffective; poison is regarded as too dangerous. The rabbit problem has therefore been transferred from the Game Department to the domain of rural economics. The rabbit to-day in Gotland constitutes such a menace to sylviculture and agriculture that it is ranked with the small rodents. Work is now being undertaken on the introduction of the virus disease *Myxomatosis cuniculi* into the Gotland rabbit population. These trials are on similar lines to those already in operation in Australia, where considerable success has already been reported (see *Nature*, 170, 7; 1952), and it will be interesting to see how the results in the two different hemispheres will eventually compare.

Problems in the Calculation of Interplanetary Orbits

In a paper on "Interplanetary Orbits" (*J. Brit. Interplanetary Soc.*, 11, No. 5, September 1952), J. G. Porter points out two fundamental errors in dealing with interplanetary travel (the discussion being

limited almost entirely to the earth–moon system) which should be noted by all serious students of astronautics. First, although computers use seven-figure tables, probably only five figures are trustworthy, because the co-ordinates of the sun and planets are doubtful beyond five decimal places in astronomical units, and in consequence of this considerable errors in miles or kilometres are inevitable in many of the calculations. The second possible source of error arises from the fact that the movements of the bodies in our solar system may not be amenable to accurate treatment by the old classical mechanics. Porter gives a number of instances where important factors have been more or less ignored in the computations. For example, some have asserted that it would be economical to send a space ship to the neutral point between the earth and the moon, this point being about 24,000 miles from the moon, and then to allow it to fall relatively slowly towards the moon. But, as Porter points out, the attraction of the sun is nearly double that of the earth or the moon at the neutral point, and this would control the ship, which would then describe an orbit about the sun. Even if the supposed possibilities regarding the neutral point are completely excluded from consideration, difficulties of a serious nature would arise in other ways.

If it is decided to travel to the moon in an elliptical orbit, the speed of approach to the moon will be so high that a large amount of fuel must be used in braking (in the paper some figures are given on this matter) and, instead of travelling in an elliptical orbit for nearly five days to reach the moon, it would be as efficient to travel in a parabolic orbit which would require a little more than two days. Another difficulty arises if a ship is perturbed by some other body because, though there may be a small increase in the acceleration, nevertheless when this has ceased the velocity increase remains and the effect on the distances can be very great. All this demands that the initial conditions of velocity, distance, and angle of projection of the ship should be accurately determined; but even with the greatest accuracy, occasions will arise when pre-computed orbits will require modification. How such modifications could be computed during flight may present serious problems to future interplanetary navigators.

Temperature of the Chromosphere

A PAPER by Shotaro Miyamoto on the "Kinetic Theory of the Chromosphere" (*Pub. Astro. Soc. Japan*, 3, No. 2 (1951), and also *Contrib. Inst. Astrophys., Kyoto Univ.*, No. 17) examines all the available data regarding the temperature of about 30,000° C. of the corona, and points out the difficulties of accepting this high temperature. Redman derived it from the contour observation of the chromosphere emission lines at the eclipse of October 1, 1940 (his results appearing in *Mon. Not. Roy. Astro. Soc.*, 102, 140; 1942); but Miyamoto gives a number of reasons for disagreeing with these results. He does not, however, attempt to complete the low-temperature hypothesis, but refers to the paper by Woolley and Allen on "Ultra-Violet Emission from the Chromosphere" (*Mon. Not. Roy. Astro. Soc.*, 110, 358; 1950), which appeared after he had written his paper. Miyamoto claims that they are in general agreement with his low-temperature hypothesis, and, while admitting the anomalous excitation of the chromosphere as an observational fact, he does not accept this as necessarily implying a high kinetic temperature.

Journal of the Madras Institute of Technology

THE Madras Institute of Technology, which is situated at Chromepet, fourteen miles from Madras, was founded in July 1949, and now the first number of its *Journal* has appeared (1, No. 1; August 1952. Rs. 4, 8*s*. or 1 dollar per issue; Rs. 8, 16*s*. or 2 dollars a year), edited by the professor of applied mathematics in the Institute, Dr. A. Narasinga Rao. The Institute was started with a gift of Rs. 500,000 from Sri C. Rajam, a grant of Rs. 500,000 from the Madras State Government and a number of smaller gifts from various organizations and persons. It deals with education and research (pure, applied and sponsored) in the physical sciences, engineering and technology, and until now it appears to have concentrated mainly on the educational side—and rightly so; but the time is fast approaching when the research activities will play an equally important, if not the major, part in the life of the Institute, and it is therefore fitting that the *Journal* should be started, wherein the fruits of new knowledge can be published. The Institute offers courses extending over three years, during the first year of which the students follow for the most part a general course in the basic sciences (mathematics, physics and chemistry) and basic engineering subjects. After that they specialize in one of the four faculties, which are as follows (numbers of second- and third-year students in each faculty being shown in brackets): aeronautical engineering (10, 24), automobile engineering (24, 23), electronics (28, 18), and instrument technology (8, 7). After a short description and faculty notes on the activities of the Institute, the main part of the first number of the *Journal* is devoted to articles as follows: "Aeronautical Science To-day", by Dr. W. Repenthin, head of the Faculty of Engineering of the Institute; "Numerical Calculations in Electrical Engineering and Electronics: Part 1, Calculation of Determinants", by Prof. R. Filipowsky, head of the Electronics Faculty of the Institute; "Oxidation of Hydrocarbons", by Dr. S. V. Anantakrishnan, visiting professor of chemistry in the Institute; "Note on a Method of Transient Analysis", by K. K. Clarke, of the Electrical Engineering Department, University of Ceylon; "On the Kalidasa Effect", by Dr. A. Narasinga Rao; "Introduction to the Giorgi System of Units", by Dr. R. Wallauschek, head of the Faculty of Instrument Technology in the Institute; "Patent: its Law and Practice", by Prof. V. Subramanian, visiting professor of the Institute; and "On a Method of measuring very Small Time Intervals", by A. Suszkin, laboratory research engineer in the Institute. A number of short notes completes the issue.

Fusarium Contamination of Grain

THE prevalence and taxonomy of *Fusarium* species in cereal seed in Canada is considered in detail in a recent paper by W. L. Gordon, of the Dominion Laboratory of Plant Pathology, Winnipeg (*Canad. J. Bot.*, 30, No. 2, 209; 1952). In all, of about four thousand seed samples of wheat, barley and oats which have been examined (a hundred kernels per sample), the statistics show considerably heavier infections in Eastern than in Western samples. A total of sixteen species and varieties of *Fusarium*, classified in nine sections of the genus, was isolated. (The classification used is that of Wollenweber and Reinking, but some sections have been extensively revised in conformity with the views of Snyder and

Hansen.) Detailed diagnoses, line illustrations of conidia and chlamydospores, and some good photographs in colour of monoconidial cultures of the wild type of each species, variety or form are given.

Chromatography of Phycocyanin

E. C. Wassink and H. W. J. Rageth have reported on a paper chromatographic analysis of the blue solution obtained by the acid hydrolysis of the photosynthetically active chromoprotein, phycocyanin, of the blue-green algæ *Oscillatoria* (*Proc. Koninkl. Nederlandse Akad. van Wetensch.*, Ser. C., LV, **4**, 462; 1952). The analysis yielded sixteen amino-compounds of which thirteen were known amino-acids and three were unknown substances, one of these last being present in relatively large amount. Arginine was absent; but otherwise the assay of the *Oscillatoria* phycocyanin did not reveal important differences from the bulk proteins of the green algæ *Chlorella vulgaris* (with chloroplast proteins) or from horse hæmoglobin.

Blundell's School Science Society

The seventh issue of the Blundell's School Science Society magazine again shows the remarkably fine work being done at boarding schools in Britain in the training of young scientists. One article, for example, describes some studies of the biology of ivy-leaved duckweed (*Lemna trisulca*) by a senior boy, M. J. Corrigan. Among the questions he investigated were methods of encouraging growth, the effect of temperature and the role of auxin on growth, the growth of the plant under different wave-lengths and intensities of light, as well as the reasons which cause *Lemna trisulca* to sink to the bottom of a canal in winter and to cause its fronds to float just below the water-surface at other times. Corrigan's article is supported by two others by boys who, like him, have been awarded school prizes for their original work. The magazine also describes the many meetings held by the Science Society during 1951–52 and the records compiled by individual members and sub-committees of the Society in and around Tiverton. In addition there is an admirable account by two boys of a recent visit to an old but recently resuscitated iron-works at Dunsford.

Fourteenth International Congress of Zoology, Copenhagen

The Fourteenth International Congress of Zoology will be held in Copenhagen during August 5–12. It has been decided to have a fairly large number of sections, so that comparatively specialized fields can be discussed, and a provisional list of sections (with the name of each organizer) has been arranged as follows: nomenclature (Dr. H. Lemche), invertebrate palæozoology (Prof. Chr. Poulsen), vertebrate palæozoology (Dr. E. Nielsen), quaternary zoology (Dr. M. Degerbøl), zoogeography (Prof. R. Spärck), speciation (Dr. F. Salomonsen), genetics of populations (Dr. H. Lemche), cytology (Dr. H. Holter), sub-microscopical structure of animals (Prof. H. V. Brøndsted), animal regeneration (Prof. H. V. Brøndsted), morphogenesis (Prof. H. V. Brøndsted), animal psychology and ethology (Dr. H. Poulsen), comparative physiology (Prof. P. Brandt Rehberg), parasitology (Prof. M. Christiansen), nematology (Dr. P. Bovien), terrestrial ecology (Dr. Ellinor Bro Larsen), marine ecology (Dr. G. Thorson), entomology (Dr. S. L. Tuxen), vertebrate systematics (Dr. M. Degerbøl) and invertebrate systematics (Dr. P. L. Kramp). Four general meetings have been planned at which lectures lasting about an hour will be given on topics of general interest, followed by discussion. At the section meetings a specialist will be invited to give a lecture lasting about forty minutes, which will cover a central problem of the section concerned; added to this, members may read short papers, not more than twenty minutes in duration, and also give brief demonstrations of animals, slides, films, etc. The official languages of the Congress will be English, French and German. All who wish to contribute to the proceedings or reserve hotel accommodation should communicate with the secretariat before April 15; the last date for membership registration is June 1. All communications should be addressed to the secretariat of the Congress at Krystalgade 27, Copenhagen *K*.

Immediately before the Congress a colloquium, organized by Mr. Francis Hemming, will be held by the International Commission on Zoological Nomenclature, officially representing the International Union of Biological Sciences. During the Congress a colloquium will be held on "Zoogeographical Problems of the Deep-Sea Fauna", organized by Prof. R. Spärck.

Rumford Bicentenary Celebrations in the United States

The bicentenary of the birth of Benjamin Thompson, Count Rumford, on March 26, 1753, will be celebrated in the United States at Boston, during March 26–28, by the American Academy of Arts and Sciences. The social functions in the celebrations will be a dinner on March 26, at which Sanborn C. Brown, of the Massachusetts Institute of Technology, will give an account of his researches into the life of Rumford, and on March 27 a ceremony will be held at which Rumford Medals of the Academy will be presented to Profs. E. Fermi, W. E. Lamb, jun., and L. Onsager. In addition, during the morning and afternoon of March 27 and the morning of March 28, respectively, the following three symposia will be held, at which the speakers will be as shown: recent developments in thermodynamics (Prof. P. W. Bridgman, Harvard; Sir Alfred Egerton, London; Prof. L. Onsager, Yale; and Prof. F. E. Simon, Oxford); recent developments in atomic spectroscopy (Dr. M. Deutsch, Massachusetts Institute; Prof. W. E. Lamb, jun., Stanford; Dr. E. M. Purcell, Harvard; and Prof. I. I. Rabi, Columbia); and recent developments in nuclear physics (Prof. E. Fermi, Chicago; Prof. J. R. Oppenheimer, Institute for Advanced Research, Princeton; Prof. M. Siegbahn, Nobel Institute, Stockholm; and Prof. V. F. Weisskopf, Massachusetts Institute).

The Night Sky in March

New moon occurs on March 15d. 11h. 05m., U.T., and full moon on March 30d. 12h. 55m. The following conjunctions with the moon take place: March 4d. 23h., Saturn 8° N.; March 17d. 20h., Venus 2° N.; March 17d. 20h., Mars 5° S.; March 19d. 06h., Jupiter 6° S. In addition to these conjunctions with the moon, Venus is in conjunction with Mars on March 17d. 23h., Venus being 7° N. Mercury sets at 19h. 20m. at the beginning of the month, but draws closer to the sun and is in inferior conjunction on March 18, after which it becomes a morning star, being, however, too close to the sun for observation during the remainder of the month. Venus, an evening star, sets at 21h. 55m., 21h. 45m. and

20h. 50m. at the beginning, middle and end of the month, respectively, and is conspicuous in the western sky for some time after sunset. The visible portion of the illuminated disk varies between 0·332 and 0·070 and the stellar magnitude averages about − 4·2, the greatest brilliancy (magnitude − 4·3) being attained on March 8. Mars is visible in the early part of the night, and sets at 20h. 55m. approximately throughout the month. About the middle of the month it is a little north of o Piscium, and later it moves into the constellation of Aries. Jupiter sets at 23h. 35m., 23h. 20m. and 22h. 15m. on March 1, 15 and 31, respectively, and lies a little south of δ Arietis during the greater part of the month. Saturn rises at 21h. 50m., 20h. 50m. and 19h. 35m. at the beginning, middle and end of the month, respectively, its stellar magnitude being 0·6, and lies a little north-east of Spica. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: March 19d. 21h. 15·9m., 16 Taur. (*D*); March 19d. 21h. 23·5m., 17 Taur. (*D*); March 19d. 21h. 34·6m., *q* Taur. (*D*); March 19d. 21h. 42·9m., 20 Taur. (*D*); March 19d. 22h. 03·1m., 21 Taur. (*D*); March 19d. 22h. 34·0m., η Taur. (*D*); March 22d. 23h. 50·6m., ε Gemi. (*D*); March 23d. 0h. 48·0m., ε Gemi. (*R*); March 26d. 0h. 53·4m., π Canc. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. Vernal equinox occurs on March 20d. 22h.

Announcements

MR. DONALD W. HUDSON, chairman of the National Pharmaceutical Union and a member of the Council of the Pharmaceutical Society, has been appointed an Officier de l'Ordre de la Santé Publique in recognition of his services as chairman of the Franco-British Pharmaceutical Commission.

MR. H. TREFOR JONES, deputy provincial director, Yorks and Lancs Province of the National Agricultural Advisory Service, has been appointed provincial director of the Province in succession to the late Mr. D. H. Findlay.

MR. J. RANNIE, welding engineer to John Brown and Co., Ltd., of Clydebank, has been awarded the William J. Larke Medal for 1952 of the Institute of Welding for his paper "Shipyard Changes with special reference to Steelwork Construction in Oil Tankers".

DR. C. M. WHITTAKER, an honorary fellow of the Textile Institute and former director of Courtaulds, Ltd., will deliver the Mather Lecture for 1953 of the Institute, following the annual general meeting at the University of Bristol on April 29. Dr. Whittaker will speak on "Common Sense on Colour in Textiles".

THE Institute of Metals has awarded the 1952 W. H. A. Robertson Medal and a premium of fifty guineas to Mr. J. F. Waight, an engineer of the West Midlands Gas Board, for his paper on "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys" (*J. Inst. Metals*, **80**, 269; 1952). This Medal, which was given by W. H. A. Robertson and Co., Ltd., is awarded annually for the encouragement of the writing and publication in the Institute's *Journal* of papers on engineering aspects of non-ferrous metallurgy.

TRINITY COLLEGE, Cambridge, is offering as in former years a number of research studentships and Dominion and Colonial exhibitions, which will be tenable from next October. The research studentships, which will not exceed £375 a year for a maximum of three years, are open to graduates of universities other than Cambridge (non-graduates of exceptional ability will be considered) who are not more than twenty-six years of age (although time spent in national service may be deducted) and who have not already spent more than two years on advanced study or research. The exhibitions are for students from the British Dominions and Colonies who intend to read for an honours degree, and are worth £40 a year. Applications, to be sent through the head of the candidate's university, must reach the Senior Tutor, Trinity College, Cambridge, not later than May 1.

THE Massachusetts Institute of Technology is offering a number of graduate and advanced research fellowships for study and research in the field of electronics. Graduate student fellowships are for work leading to advanced degrees in physics or electrical engineering and are worth 1,500–2,400 dollars a year; advanced research fellowships, which are worth upwards of 3,000 dollars a year, are for those possessing a Ph.D. degree or its equivalent who wish to pursue advanced studies and research in the field of electronics at the Institute. Applications for these two classes of fellowships should be made to the Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass., at least four months prior to the intended date of entrance. A limited number of positions are also available for students to work as research assistants in the Research Laboratory of Electronics while at the same time pursuing a graduate programme of studies on a part-time basis; further information regarding this scheme can be obtained from the Director of the Laboratory.

A FULL-DAY conference will be held by the Northern Branch of Aslib on March 12 in the Council Chamber of the Town Hall, Stoke on Trent, under the chairmanship of Colonel G. A. Wade, chairman and managing director of the Wade Group of Potteries. Four lectures will be given as follows: the Iron Library, by W. B. Ingram (Britannia Iron and Steel Works, Ltd., Bedford); the British Ceramic Research Association Information Department, by A. E. Dodd (British Ceramic Research Association); historic pottery, by G. I. V. Bemrose (curator, Stoke on Trent Public Museum); and Aslib, what it is and what it does, by Leslie Wilson (director of Aslib). The fee for the conference is 3*s*. 6*d*. Visits have been arranged to various firms and institutions on March 13. Further information can be obtained from Dr. J. C. Withers, "Penmere", 11 Highfield Park, Heaton Mersey, Stockport.

A REPORT of the proceedings of the British Commonwealth Scientific Conference, held in Australia, February–March 1952 (see *Nature*, **169**, 856; 1952), has now been published. Besides the opening address of the Prime Minister of Australia and Sir Ben Lockspeiser's reply, and the preliminary statement by the chairman, Dr. I. Clunies Ross, it includes the recommendations and resolutions of the Conference and the text of a statement on the national organization of research adopted by the Conference in full session. Appended are a list of committees and their composition and a summary of action taken on resolutions of the British Commonwealth Scientific Official Conference, 1946.

PROTECTION FROM THE EFFECTS OF RADIATION

RADIATION protection was the subject for discussion at a joint meeting of the Industrial Radiology Group of the Institute of Physics and the Hospital Physicists Association, which was held at the Royal Institution, London, during January 16–17. From the papers given by the various speakers one could piece together the past history of this subject and the present quickening interest in it.

Dr. L. H. S. Clark described the service which had been established nearly twenty years ago at the Lambeth Hospital to ensure adequate protection of the staff of the radiological departments. Film badges of fast dental film were found satisfactory as means for measuring the doses of X-rays received by the individual in the course of his work. This was no isolated instance of the growing awareness of the need for protection against the damaging effects of ionizing radiation. Tribute was paid to the splendid work of the British X-ray and Radium Protection Committee which, from its inception under the chairmanship of the late Sir Humphry Rolleston and often without financial support, did heroic pioneer work.

Although many individual hospitals or groups of hospitals were taking steps to protect their staff, this was not universally so, and in 1942, as a result of the efforts of the late Dr. A. E. Barclay, it was deemed necessary to have an external monitoring service for those institutions in the Emergency Medical Service where no internal service was maintained. Mr. E. E. Smith described how the National Physical Laboratory was asked to undertake this office and how it solved the problem. Although the degree of blackening of film is dependent on the quality of the radiation applied, nevertheless it was chosen at that time because the available ionization chambers were fragile and liable to misuse. Moreover, with a service conducted by correspondence, the methods had to be as simple as possible. From small beginnings with the receipt of a few hundred films a month, the service supplied by the National Physical Laboratory has steadily progressed. Workers in factories and research laboratories were soon added to the list of customers, and an inspection service was set up to advise those bodies whose workers consistently recorded high doses. Now, about five thousand films a month are processed by five technicians, and happily the proportion of recorded doses above tolerance is steadily diminishing.

These early theoretical and practical aspects were by no means confined to Great Britain. An International Protection Commission had met on several occasions and reported its recommendations; it still continues to do so, the last meeting being in 1950. Dr. J. F. Loutit recalled some medical and biological evidence of the damaging actions of ionizing radiations which the Commission has taken into account in formulating its latest recommendations on permissible doses. It has rightly been chiefly swayed by the medical evidence where man rather than the experimental animal has suffered and even died from excessive exposure. Mr. W. Binks, himself a prominent member of the Commission, also stressed the delayed action of these effects, but appealed for a balanced approach to the problem. Respect, but not fear, on one hand, or foolhardiness, on the other, is to be encouraged, and then this hazard like others can be controlled. He quoted the figures of permissible doses of the various types of radiation so far considered. As regards penetrating radiation, he issued a note of warning that many of the published tables of transmission through lead and concrete are out of date in that narrow beams only are considered. Nowadays broad beams are more frequently in operation, and the transmissions here are vastly greater. Mr. Binks appealed for still more effort in investigating the fundamental biological action of radiation and the early incorporation of new knowledge into codes of practice. He hoped that these wishes would be implemented by a new national protection organization established jointly by the Medical Research Council and Ministry of Health.

The most modern methods of measurement of dose by means of films were reviewed by Dr. G. Spiegler. It is necessary to measure, on one hand, the hard gamma-ray radiation of radioactive isotopes and, on the other, the relatively soft emissions of diagnostic X-ray machines or the scattered rays from radioactive sources. Thus the monitoring film contains an exposed portion to record the combined soft and hard radiation and a portion or portions protected by aluminium, brass, lead, cadmium or other appropriate filter to measure the harder components. By contrast, with very hard rays of energy greater than 2 MeV., there is a reversal of the usual picture and less blackening of the unfiltered area.

Whereas X-ray film is still the main standby for the measurement of dose, ionization chambers also play their part. Dr. E. Dyson described some of those in use at the Atomic Energy Research Establishment, Harwell. Large ion-chambers are used for area monitoring; but by themselves they would be inadequate because of the variation in scattering under altering conditions. The personal dosemeter is a necessary addition. For specific purposes this can be either a condenser-type chamber which is charged and after use read by various electrometers, or a quartz-fibre electrometer which the wearer can himself read and assess the rate of accumulation of dose. With radiation of 100 keV. and more, the variation of the reading with hardness of the rays is of the order of $\pm$ 10 per cent. These electrometers are somewhat sensitive to hard beta-rays.

As modern research and development makes available X-rays of greater and greater energy and radioactive sources of greater activity, industry is finding increasing use for them, particularly in engineering for testing purposes. Dr. C. Sykes noted that, while each source is obtained for a specific purpose, the applications multiply. The increasing time and scope of use of these sources make the originally devised protective arrangements inadequate. If the job is brought to the source, protection should not be difficult; but when the source is taken to the job, it is not simple to give adequate protection without disturbing the normal routine of the workshop. This increasing use, particularly of radioactive isotopes, by firms with no previous experience of the subject and therefore no competent medical officer or physicist, exposes the need for a set of rules clear even for factory managements.

Dr. H. Harris (Babcock and Wilcox, Ltd.) and Dr. J. S. Blair (Stewart and Lloyds, Ltd.) carried the discussion further from the point of view of industry.

In their experience the literature on protection is not readily available ; but a competent engineer can solve his problems by common sense and by insisting on a rigid discipline among the operating staff.

The legal responsibility for the health and welfare of workers in factories, but not in research laboratories, lies with the Ministry of Labour. Mr. K. Goodall (H.M. inspectorate of factories) described how this Ministry watches for new hazards and advises on old ones. In the case of sealed sources of radioactive isotopes, the position is at present satisfactory in that the Ministry is informed from Harwell or Amersham of the delivery of all such consignments to new customers. Present records show surprisingly few accidents, and Dr. Ethel Browning's hæmatological data contain few abnormalities. With the existing policy of persuasion, results are as satisfactory as would be expected if regulations were in force ; the greatest danger, said Mr. Goodall, still remains not the closed sources of radioactivity but the open sources met with in the luminizing industry.

In industry, according to the evidence presented, the care or discipline exercised has resulted in the workers receiving doses well below tolerance (an average of about 10 mr./week in one case). By contrast, in the Ordnance Inspectorate of the Royal Navy, as it appeared from Commander P. Chandler's remarks at the meeting, policy is determined by the delivery of the goods and not by the hazard to the staff. This attitude may be necessary in the Armed Forces in time of war, but was alarming to the medical section of the audience.

ROYAL ASTRONOMICAL SOCIETY

PRESENTATION OF GOLD MEDAL

At the meeting of the Royal Astronomical Society on February 8, 1952, at Burlington House, London, the Gold Medal of the Society was presented to Dr. John Jackson by Prof. H. Dingle, the president of the Society, who gave an address which has since been published in full (*Mon. Not. Roy. Astro. Soc.*, 112, 3 ; 1952).

Not very long after Dr. Jackson had finished his career at Cambridge he went, in 1914, as chief assistant to the Royal Observatory, Greenwich, where about twenty years of work on double stars with the 28-in. refractor awaited analysis, and this task was undertaken by Jackson in collaboration with Furner. There were also available F. G. W. Struve's results, published in 1837, which included 3,112 close pairs, and many more were added by the late Otto Struve, who continued his father's work. Jackson showed that 649 of F. G. W. Struve's stars had changed their configuration since his day ; of these, 449 showed true orbital motion, 161 were optical doubles the components of which differed in proper motion, and in 39 the nature of the motion was uncertain. Among Otto Struve's stars he found that 135 were binaries, 15 optical doubles and 5 had doubtful motion. The results of the analysis were published in a number of papers in *Monthly Notices of the Royal Astronomical Society* from 1920 onwards, and the hypothetical parallaxes deduced agreed well with the trigonometric and spectroscopic parallaxes which were then available. The next step was the determination of the cross-components of the velocities of the stars from their known proper motions, from which the apex and speed of the solar motion were determined, and these showed good agreement with those found by other methods. The absolute magnitudes of the stars were also determined from their apparent magnitudes, and this provided further evidence for the separation of the stars of the later spectral type into giants and dwarfs, which had been investigated by Hertzsprung and Russell some years previously and gave strong support to Russell's theory of stellar evolution.

During 1924–30 Jackson carried out valuable work on time measurement. Two Shortt free-pendulum clocks, the running of which was in charge of W. Bowyer, acting under Jackson's direction, were installed at the Royal Observatory in 1924 and 1926, and four papers on their behaviour up to the end of 1930 appeared in the *Monthly Notices*. An analysis of the errors showed that these could be reduced to three terms, one due to nutation causing non-uniformity of sidereal time, another arising from temperature fluctuations, and the third—the 'secular term'—the origin of which was not immediately obvious but which was later attributed to a gradual increase in the length of the invar rod of the free pendulum. Other possible causes, however, were conceivable, and subsequent observations cast doubts on the supposition that the gradual growth of the invar rod was the main cause of the secular term. The conclusion was that the most that could be hoped from these clocks in detecting fluctuations in the earth's rotation was that they might determine whether erratic changes of $1{\cdot}0^{s}$ a year in the moon's longitude could be due to irregularities in the earth's rotation period. One very valuable result of the whole investigation was the discovery of the nutation effect, showing the necessity for distinguishing between apparent and mean sidereal time.

In 1930 Jackson published an analysis of observations made with the Greenwich Cookson zenith telescope ; this indicated that the value of the constant of nutation was $9{\cdot}2066'' \pm 0{\cdot}0055''$, which was smaller than the value used in the ephemerides. The latter, based on Newcomb's determination from a very long series of observations, agreed very well with a more recent determination by Przybyllok, and a discordance between this and the theoretical value, considerably larger than the probable error, requires some explanation. Jackson regarded it as "one of the outstanding discordances of the constants of the solar system" ; but, as Prof. Dingle remarked in his address, it is unlikely that the last word has yet been said concerning the theoretical value.

In 1925 Jackson began to collaborate with Knox-Shaw and Robinson, of the Radcliffe Observatory, Oxford, on the reduction of Hornsby's meridian observations. The observations selected for reduction were those made between 1774 and 1798, and included about 43,000 observations of stars, 5,200 of the sun, 4,600 of planets, and 1,200 of the moon. From the results it was possible to apply systematic corrections to Boss's "Catalogue" and also to Newcomb's tables of the sun's longitude, and to other elements of the sun's apparent orbit about the earth—the equinox, the obliquity, the eccentricity and the longitude of perigee. The main publication appeared in 1932 and was followed with a paper in the *Monthly Notices* on the observations of Mercury ; these observations were specially important in checking the motion of the planet's perihelion.

In 1933 Dr. Jackson succeeded Sir Harold Spencer Jones as His Majesty's Astronomer at the Cape of Good Hope, and until his retirement in 1950 his work

there followed the main lines laid down by his predecessor. The programme consisted of three parts: the parallax work, the determination of positions and proper motions of stars in the Cape astrographical zones, and the compilation of a "Photographic Zone Catalogue" for the region − 30° to − 90° in declination. Spencer Jones's programme, inaugurated in 1926, was the measurement of the parallaxes of all possible stars of proper motion exceeding 40″ a century south of declination − 10°. Although a number of determinations had been made when Jackson assumed office, the greater part of the programme remained to be executed, and results were published from time to time in the *Monthly Notices* and in three successive volumes of the *Cape Annals*, which were edited by Jackson. In his annual report for 1949 Jackson announced that 1,623 parallaxes had been determined since the work started and that it was then almost completed. The results of the second part of the programme were published in 1936 under the titles "Proper Motions of Stars in the Zone Catalogue of 20,843 Stars, 1900, Zones − 40° to − 52°, derived from the Photographs taken at the Royal Observatory, Cape of Good Hope", and in 1939 in "Catalogue of 20,554 Faint Stars in the Cape Astrographic Zone −40° to − 52°, for the Equinox of 1900·0, giving Positions, Precessions, Proper Motions and Photographic Magnitudes, derived from Photographs taken at the Royal Observatory, Cape of Good Hope". Many important statistical results were derived from this study of more than forty thousand southern stars, and the information obtained has an important significance for the future. Good progress has also been made on the third part of the programme, the compilation of a "Photographic Zone Catalogue" for the region − 30° to − 60° in declination, with the wide-angle cameras, in which programme magnitudes and colours have also been included.

Prof. Dingle referred also in his address to a number of other tasks which Dr. Jackson has undertaken at the Cape; but it is sufficient in this résumé to quote Prof. Dingle's words that "The Gold Medal of our Society is bestowed for outstanding excellence of astronomical work, and for nothing else".

BRITISH DEPENDENCIES IN THE CARIBBEAN AND NORTH ATLANTIC

PROF. W. M. MACMILLAN'S "Warning from the West Indies" was published in 1936: the 'warning' of the book's title, he wrote later, was "originally an appeal, and looked to the future". How far his warnings and those of others have been heeded may be judged by a recently issued Colonial Office publication* which surveys the history of the British territories in the Caribbean and North Atlantic during the past thirteen years. It is the fourth in a series of official reports designed to take a longer view of trends and developments than is possible in the various annual Colonial reports. The previous reports have covered the post-war period in the Far East (Cmd. 7709, 1949), East and Central Africa (Cmd. 7987, 1950), and the British islands in the southern hemisphere (Cmd. 8230, 1951). The present report extends its range backwards to 1939 and even earlier, and it does so wisely, for the situation to-day in these areas is so dependent on the circumstances of the inter-war and war years that it is impossible to understand it without reference to this background.

This point is clearly made in the first chapter of the report, "The Seeds of the Present", which summarizes the position in the period preceding the appointment of the West Indies Royal Commission of 1938–39 and the results of that Commission, and reviews the events of the war-years that followed. The Commission decided that the region was in urgent need of social services which it could not afford from its own resources or from any unassisted development of these resources that was likely in the near future. Considerations such as these in the Colonial Empire generally lay behind the establishment of the Colonial Development and Welfare Fund in 1940: in the West Indies a Development and Welfare Organization was set up with the late Sir Frank Stockdale as its first comptroller and, despite war-time shortages, much re-organization and rehabilitation were carried through. Although, as the report puts it, "the impact of the war was manifold and serious", the end of the War left the West Indies with their basic economy largely intact and with good prospects for the planning of the future.

The chapters that follow and the useful statistical appendixes present a synoptic view of the situation to-day. The survey of political and constitutional development indicates the diversity of political structure and the complexity of local government, as well as the variety of ways in which advance is being made in the different territories from representative to responsible government. It also explains both the difficulties and the prospects of federation, towards which there is a distinct movement in most of the islands and about which a further conference is to be held in London in April.

The economic outlook just before the Second World War was, to quote the Royal Commission, "not at all reassuring", on account of the depression in the main primary-producing occupations of the region and because of the problems resulting from the high natural rate of increase of population. To-day the report states that "the uncertainty of the inter-war years has gone", partly through the development of new markets and of systems of guaranteed prices, and partly because of action taken under the Development and Welfare Acts to strengthen the region's economy, particularly its agriculture. At the same time, some of the economic problems have been intensified: developments in preventive medicine, in particular, by increasing the rate of growth of population, are already increasing the demand for education and for employment. The necessity for "the more intensive use of the land with increased production of food" is as great to-day as when the Royal Commission expressed this need, and it is satisfactory to learn that since 1939 there has emerged a new approach to the question of the most efficient use of the land, for foodstuffs as well as for export crops such as sugar, cocoa and bananas. There has been progress, too, in animal husbandry, forestry, the processing and other industries, and mining (British Guiana is the world's second largest producer of bauxite, which is also now being mined in Jamaica with the financial assistance of the Economic Co-operation Administration of the United

* Colonial Office. "British Dependencies in the Caribbean and North Atlantic, 1939–1952." (Cmd. 8575.) Pp. xi+98. (London: H.M.S.O., 1952.) 3*s.* 6*d.* net.

States). Despite these and other developments, unemployment and under-employment remain serious problems, though good progress has been made in the fields of labour supervision and industrial relations.

The general emphasis of the Royal Commission's recommendations was on welfare rather than on development, and it is not surprising to find much more advance in the social services than in economic productivity. The links between the two have been discussed in Britain in recent years, and for the Caribbean were considered by Prof. T. S. Simey (one of the war-time advisers to the Comptroller for Development and Welfare) in his "Welfare and Planning in the West Indies" (1946). Although the report notes that "in recent years it has been increasingly recognised that the maintenance of improved social services calls for intensive and sustained efforts to promote economic development", it very rightly emphasizes the considerable progress made in education, medical services, and social welfare generally.

In the modern world no area can be understood in isolation from its neighbours, least of all these British islands for which, as the report states, "a co-operative policy has been a firm feature of the conduct of affairs". International relations with the United Nations, the United States, Guatemala and Venezuela are discussed, and special attention is given to the significance of the Four-Power Caribbean Commission, which is to concentrate in future less on overall research (much of which has been done) than on those activities that have direct bearing on immediate economic development—agriculture, forestry, fisheries, industrial development and housing, in that order. Reference is also made to the considerable numbers of West Indians working and studying overseas, and to their importance in the two-way process of West Indians knowing the world and being known to the world.

The Colonial Office has produced in this report a very readable, well-balanced and most valuable account of these territories and their peoples. A realistic assessment has been made of the prospects of political, economic and social development, and some at least of the probable limitations on such progress are stressed. The main interest in the period under review has lain not in the discovery of new problems but in the progress made in dealing with them, and in the increasing recognition of the importance of joint action as a means of meeting the economic and other problems of the region. "Increased productivity, as a basis for improved or even maintained standards of living, remains the fundamental need," the report concludes, "and this must be the main objective of Governments and peoples alike in the years to come." Up to a point, this survey has covered the area's problems in a comprehensive and understanding manner: yet nowhere is there any real or sustained analysis of the problems posed by the rapid growth of population in nearly all these dependencies. To-day they have some 3,200,000 people; within a generation it seems there may be five or even six million. If this is so, is not increase of population the major problem of these British territories? Are the individual governments and the Colonial Office really alive to the urgency of this aspect of the future of the Caribbean territories? They probably are, but this report will scarcely give the informed reader that impression.

R. W. STEEL

HUMIDITY OF THE UPPER TROPOSPHERE AND LOWER STRATOSPHERE

THE troposphere is the lower part of the atmosphere, and the stratosphere the upper part. Temperature in the troposphere on the whole falls with height at the rate of about 3° F. per 1,000 ft.; but in the lower part of the stratosphere it changes little with height. The troposphere and stratosphere are separated by the tropopause, a shallow layer within which the vertical temperature gradient changes rapidly. Over southern England the mean height of the tropopause is about 37,000 ft. in summer and 35,000 ft. in winter, but large variations, sometimes exceeding 10,000 ft., occur on either side of the mean. The tropopause is low over depressions and high over anticyclones.

Within the troposphere there is much mixing of air by convection currents, and this convectional stirring produces the large fall of temperature with height. The temperature distribution in the lower stratosphere is believed to be determined by radiative equilibrium in which water vapour, as the most important constituent of the atmosphere absorbing and emitting long-wave radiation, plays a predominant part. Knowledge of the water vapour content of the upper troposphere and lower stratosphere is therefore important for study of the radiative exchange of heat in the atmosphere. It is also important in connexion with both large-scale and small-scale atmospheric circulations because, provided there is no condensation of water vapour, the ratio of mass of water vapour to mass of air (the humidity mixing ratio) remains constant as the air moves. Another application is to the formation of condensation trails which are important in military aviation.

The temperature at tropopause-level is very low, rarely exceeding − 50° F. (− 45·6° C.) and being often below − 80° F. (− 62·2° C.). This makes humidity measurements difficult, because instruments such as hair hygrometers are extremely sluggish at such low temperatures. The problem of measuring humidity at this level was solved in 1942–43 with the invention by Prof. G. M. B. Dobson and Dr. A. W. Brewer of a frost-point hygrometer operating on the same principle as Regnault's dew-point hygrometer. The instrument can be carried in an aircraft; with it the first observations of humidity in the lower stratosphere have been made, and a detailed analysis of the observations taken with the instrument in the course of 130 flights between 1943 and 1950 over southern England has been published in Geophysical Memoirs No. 88 of the Meteorological Office*.

The most striking feature is the extreme dryness of the lower stratosphere. This was quite unexpected. The mean relative humidity with respect to ice at the tropopause is 41·5 per cent, but at a height of about 6,000 ft. above (more precisely at 50 mb. lower pressure) the mean is only 5 per cent. The frost point in the lower stratosphere is rarely outside the range − 80° F. to − 120° F. (− 62·2° C. to − 84·4° C.). The corresponding saturation vapour pressures are $7{\cdot}8 \times 10^{-3}$ mb. and $2{\cdot}6 \times 10^{-4}$ mb.

* Air Ministry: Meteorological Office. Geophysical Memoirs No. 88: Humidity of the Upper Troposphere and Lower Stratosphere over Southern England. (M.O. 530c.) By J. K. Bannon, R. Frith and H. C. Shellard. Pp. 36. (London: H.M.S.O., 1952.) 2s. 6d. net.

At the tropopause there is generally an increase in the magnitude of the rate of fall (lapse-rate) of frost point with height; but this increase usually holds over a shallow layer only, and higher up the lapse-rate returns to the value it had in the upper troposphere. The increase in lapse-rate of frost point at the tropopause is most marked when there is an increase of air temperature with height there. Such an arrangement is characteristic of the tropopause above depressions and is believed to occur because the tropopause moves downwards over a depression. The subsidence of the air of the lower stratosphere necessarily tends to produce an inversion of temperature and a reduction of frost point. When the tropopause is marked in the vertical temperature curve by a reduced lapse-rate and not an inversion, the lapse-rate of frost point shows no tendency to increase there. This is characteristic of anticyclones and occurs because above them the tropopause is lifted up.

The humidity observations are analysed also for variation with season and air mass and the changes which occur on passing through a frontal surface.

The height attainable by the aircraft used for making the observations was not sufficient to enable them to climb into the stratosphere when the tropopause was above about 41,000 ft., and the results have some bias towards low tropopause. It is to be hoped that measurements of humidity to greater heights in the stratosphere will become possible in the future on a routine basis. The Americans Barrett and Herndon have flown an automatic frost-point hygrometer to 100,000 ft. below a very large plastic balloon; but their apparatus (Compendium of Meteorology, American Meteorological Society, p. 1220; 1951) weighed 46 lb. Routine flights with balloon-carried apparatus must await the development of a lighter instrument.

SOCIAL SECURITY AND UNEMPLOYMENT IN LANCASHIRE

UNDER the title "Social Security and Unemployment in Lancashire", Political and Economic Planning has issued a useful broadsheet (No. 349; December 1, 1952) analysing the effects of unemployment on the working of the more comprehensive social security measures now in existence. The information was sought particularly from the cotton towns, and, although the survey is too limited to throw light on the adequacy of benefit and assistance payments, it confirmed the conclusion reached in an earlier broadsheet that actual patterns of expenditure by poorer families differ widely from that accepted as the basis of social security payments. Families appear to draw extensively on savings, and, failing these, economize on food and fuel to maintain certain types of expenditure, including even entertainment, as long as possible. The survey has shown that relatively few of the unemployed in Lancashire have applied for national assistance. This is partly due to ignorance or misunderstanding about the regulations, especially those concerning house ownership and the amount of savings which are to be disregarded in assessing need. Something less than half of those who would qualify for assistance seem ready to ask for it.

While on the whole the machinery of the scheme appears to have been put into motion quickly and smoothly, and regulations too have been administered in the spirit of the new Acts, the survey has shown that many people do not qualify for benefit, or qualify only for less than the standard amount. Most of the former are married women, and P E P makes the point that, when married women have to stay at home from time to time for such reasons as looking after their children or an invalid dependant, there is a strong case for relaxing the contribution conditions so as to enable more married women to draw benefit, either by crediting them with insurance contributions or by permitting them to continue contributions as if they were still in employment. Workers with secondary, part-time occupations are also in an anomalous position, and P E P suggests that the Ministry of National Insurance should review the regulations concerning subsidiary earnings in the light of recent experiences in Lancashire.

The evidence collected in Lancashire must obviously be interpreted with great caution for other areas; and P E P directs attention to the difficulty in making precise judgments about the working of the social services in Lancashire, because of the gaps in information which exist and the different methods by which the various official statistics are collected and presented. If for good reasons unemployment and national insurance statistics cannot be made comparable, it suggests that sample inquiries in circumstances such as those in Lancashire during recent months would provide evidence of material value to administrators and others concerned with the social services as well as to research workers.

BREEDING BEHAVIOUR OF THE SWIFT

THE breeding biology of the swift (*Apus apus*) has been studied by David and Elizabeth Lack (*British Birds*, **44**, No. 6; June 1952). The first observations were made in 1946 on birds nesting in holes in thatched roofs in villages near Oxford; attempts were made later to induce the birds to breed in nest boxes. For many years swifts had nested in the ventilators in the tower in the Museum of Oxford and, in 1948, platforms were erected inside the tower and ventilators were replaced by nest boxes to which glass backs were fitted. The observers could now sit in semi-darkness a few inches from the birds, watching against the light from their entrance holes without causing them any disturbance. The paper describes the behaviour recorded.

Most adult swifts show little fear in their boxes, presumably owing to lack of natural enemies at the nest. There is, however, great individual variation. Some were extremely tame from the start and were not at all disturbed when, in weighing experiments, the eggs or young under them were removed and later replaced. Others at first left the box if a hand were inserted, but became tame through repeated handling. Some fiercely attacked an inserted hand with their claws, and displayed if noises were heard outside the box or objects seen near the glass.

The observations showed that each year about twenty pairs laid eggs, and several non-breeding pairs, possibly in their first year, occupied other boxes. The adults arrived in spring and departed in summer over about three weeks, the two members of each pair usually arriving and departing separately. Each pair normally rested in their boxes throughout the summer.

Adults were seen to visit the boxes at any hour of the day but especially around 7.30 a.m. and 6 p.m., sometimes sheltering in the boxes in rain. In fine weather single individuals or small parties might fly up to and brush against the boxes and were treated as strangers by the pairs. When another swift entered the box it was often treated with incipient threat display. If it were the bird's own mate, the display quickly gave place to mutual preening; if it were a stranger, a fight sometimes followed. Little preliminary display took place before coitus, which occurred in the boxes.

Nest building was observed to start on the day that the pair was formed and continued until the end of incubation, the material being stuck down with saliva. Non-breeders were observed to build throughout the summer. If a clutch of eggs were lost for any reason a repeat clutch sometimes followed. Part or the whole of the clutch was sometimes ejected, the ejected eggs being sometimes fertile. The reason for ejection is still obscure.

Parent birds took an equal share in incubation, the time of each sitting varying from 2 to 345 minutes; the eggs were sometimes left uncovered during the day for periods of up to 6½ hours. Although considerable investigation was undertaken, the influence of weather on the incubation rhythm was found to be obscure. The parents brood the young by day almost continuously in the first week and for about half the time in the second week, but very little thereafter.

Feeding habits showed that the parent brings a mass of insects stuck together with saliva, this being normally passed in a single food ball to one nestling; with very small nestlings the food ball was divided. The parent swifts readily adopted a strange nestling added to or in place of their own. The parents moved some of the fæces but many others were left in the boxes, the older nestlings sometimes defæcating from the hole.

In a description of the fledging habits, Mr. and Mrs. Lack record that at Oxford most young swifts left the nests between the third week of July and the third week of August, the latest being on September 7. The young left equally in good and bad weather and departed in a steady stream, most of them leaving over a period of three to four weeks.

The young swift left the nest fully able to take care of itself and was assumed to migrate on the day that it left the nest. Nearly all the departures were in the morning, and no fledgling returned to its box. It was also reported that, in 1951 at least, most of the parent swifts stayed for several days after the departure of their young.

MAGNETIC MEASUREMENTS IN DEEP-SEA INVESTIGATIONS

Construction of Non-magnetic Containers

FOR its biological investigations the ship *Galathea* of the Danish Deep-Sea Expedition round the world during 1950–52 was equipped with a longer wire and a more powerful winch than previous deep-sea expeditions. Due to this and the fact that the construction of magnetometers of high precision has been specially developed in Denmark through the work of the late D. la Cour, it was thought natural to take up on the *Galathea* expedition also the problem of measuring the variation in the oceans with depth below sea-level of the magnetic field of the earth. The problem of the origin of terrestrial magnetism being still an open question, such measurements may elucidate this problem, which has become of special interest through the recent investigations of Blackett, Bullard and Elsasser. In this and the following note is described the work with this object.

To contain the magnetometers and protect them against the pressure of the water, which at the greatest measured ocean depths was about 1,000 atm., special water-tight containers had to be constructed of a non-magnetic and sufficiently strong material. None of the existing alloys known to us fulfilled both requirements except the aluminium alloy 'Hiduminium *RR*77'. Unfortunately, this alloy cannot be cast but only forged, a procedure which could not be used due to the limited economic resources and time at our disposal. However, Messrs. Paul Bergsøe and Son produced a new alloy satisfying all our requirements. This alloy is a completely iron-free β-manganese bronze with a high content of aluminium. Its characteristics are: magnetic permeability, less than 1·01; elastic limit, 28 kgm. per mm.^{2}; 0·01 per cent limit, 29 kgm. per mm.^{2}; 0·2 per cent limit, 38 kgm. per mm.^{2}; tensile strength, 70–80 kgm. per mm.^{2} at an elongation of 10–20 per cent; Young's modulus, $E = 6{,}100$ kgm. per mm.^{2}; density, 8·1. (A detailed account of this alloy is to be published shortly in Great Britain.) Messrs. Burmeister and Wain constructed two containers of this material, which for mechanical reasons were made in the form of spheres. The first container, shown in Fig. 1, is a single sphere, internal diameter 50 cm., wall thickness 10 cm., weight 1,100 kgm. The second container, shown in Fig. 2, consists of two single spheres like the former, connected by a tube 100 cm. long. Its total height is 270 cm. and total weight 1,700 kgm.

From experience with diesel engines, the containers were made water-tight without any packings, simply by direct contact between the polished surfaces of the single half-spheres, which were made as plane as technically possible.

The double sphere has been lowered four times to a maximum water depth of 6,900 m. It was found to be completely water-tight on all four occasions. The single sphere has been lowered twenty-nine times to various depths down to a maximum of 10,000 m. in the Philippine Trench. At the beginning some water leaked into the single sphere. This was found to be due partly to casting stresses, which gradually disappeared, and partly to the surfaces of its two halves being not perfectly plane, thus needing extra grinding and checking by means of a normal plane. In this way we reduced the leakage to the insignificant amount of 40 cm.^{3} at a depth of 5,000 m. Lack of time did not allow us to make further experiments to remove this residual water.

Finally, the elastic properties of the containers were tested. For this purpose the horizontal internal diameter of 500 mm. was measured before and after the descent of the single sphere to 10,000 m. in the Philippine Trench. A reduction of diameter of at most 0·04 mm. was found. The corresponding figure for the double sphere at a depth of 6,900 m. was 0·01 mm. Also the elastic reduction of the spheres while lowered was measured. At a depth of 6,900 m. we found that for the double sphere the vertical internal diameter of 500 mm. had been reduced by

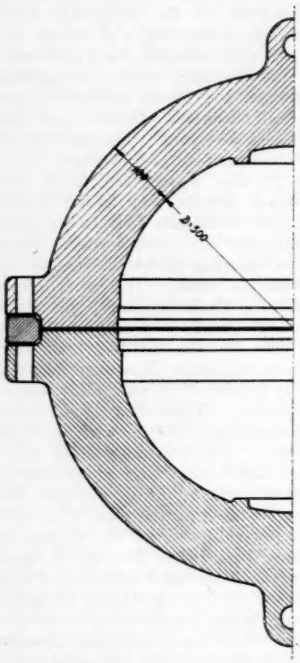

Fig. 1

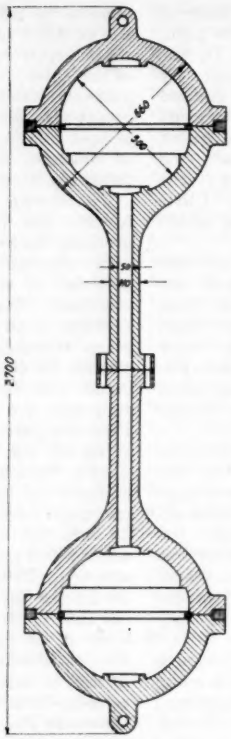

Fig. 2

at most 1·2 mm., that is, by an amount not exceeding 0·24 per cent.

Thus our results show that it is possible to construct containers allowing ordinary magnetic and other physical instruments to be lowered to even the greatest ocean depths. Apart from magnetic work, these spheres may also be used for gravimetric, seismic, cosmic ray and other work. We shall be very pleased to put our spheres at the disposal of others for such investigations.

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Magnetic Investigations on the *Galathea* Expedition

Three self-recording, relative magnetometers have been constructed: (*a*) and (*b*) measuring the horizontal component H, and (*c*) measuring the vertical component Z. The principle of (*a*) and (*c*) is that the deflexion of a magnetic needle of the la Cour monad type from a vertical and a horizontal position, respectively, is measured optically on a moving photographic film. The principle of (*b*) is that the earth's field induces an alternating current in a coil rotating about a vertical axis. This current is recorded on a magnetic recorder after having been amplified by an electronic amplifier, the amplification of which is inversely proportional to the frequency with which the coil rotates. Instruments (*a*) and (*c*) are housed successively in the single sphere, (*b*) in a double sphere, described in the preceding communication. The lower sphere of the double sphere contains the coil driven by an axle through the tube, with a motor in the upper sphere, which contains also the batteries for the motor, the amplifier and its batteries, and the recorder. To obtain sufficiently high measuring accuracy in all three instruments, most of the field to be measured is compensated by suitable magnets, so that only a small fraction is actually measured. Furthermore, in (*a*) and (*b*) these compensating magnets have the form of compass needles to give the direction of the magnetic meridian.

Within a total time of about 270 hr. which could be spent on magnetic work at sea during the expedition, our instruments were lowered twenty times to various depths of water down to 5,000 m. The first part of our programme was to make trial experiments with the instruments and adjust them to the working conditions at sea, to work out the method of observation such as manœuvring the ship, checking the tables of Vestine *et al.*[1] which form the basis for the adjustment of the instruments, investigating the perturbing effect of the ocean bottom, and so on. The second part of the programme was to use the results of the first part to take measurements at a depth of water of 5,000–6,000 m. in the central part of the Pacific Ocean, which offers great areas with flat bottom. However, due to lack of funds to meet the rising prices, the working time of the expedition had to be cut down. Thus lack of time prevented us from carrying out the second part of our programme.

The main problem in reaching the desired measuring accuracy, namely, about 10 γ, was found to be the fact that due to the weight of the spheres the wire unwound itself, thus rotating the spheres about the vertical with speeds too fast for the instruments. (To investigate both the rotation and oscillations of the spheres a special instrument was constructed recording the motion of the spheres.) This problem was solved by means of a special ball-bearing swivel inserted between the sphere and the wire, a 3-m. long aluminium rudder on the sphere, and finally by manœuvring the ship in such a way that at each depth at which magnetic measurements were taken the sphere moved horizontally at about 1 knot, which speed was found to be sufficient for the rudder to keep the spheres in a definite azimuth.

The following results were obtained. A method has been worked out whereby in any event an average value for H with an accuracy of about 5 γ can be measured within an hour down to at least 3,000–4,000 m. Furthermore, at a given depth at which magnetic measurements were taken the observed variation of the field with the position of the sphere showed that a rugged ocean bottom gave considerable perturbations as long as the

instruments were not at least 2,000–3,000 m. above the bottom. Finally, we found that at most stations the tables of Vestine *et al.*[1] agreed surprisingly well with the field we observed. However, at a few of our stations in the Pacific we observed anomalies where the field deviated by about 500 γ in *H* and about 1,000 γ in *Z* from the values given in the tables.

Although on the stations given by the plan of the expedition it was not possible to eliminate with certainty the perturbing effect of the bottom, all our measurements indicate that both *H* and *Z* increase numerically with increasing depths below sea-level. These findings are in agreement with what has recently been found in mines by Runcorn *et al.*[2]. Lack of time prevented us from obtaining on this expedition a physically reliable measurement of the vertical gradient of the field independent of the perturbing effects of the bottom, but we hope to be able to utilize our experiences and results on future deep-sea expeditions, and we ask anybody planning such expeditions to get into touch with us to consider the possible continuation of this work.

A detailed account of the present work will be published in the *Journal of Geophysical Research*.

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[1] Vestine, Lange, Laporte and Scott, "The Geomagnetic Field" (Washington, 1947).
[2] Runcorn, Benson, Moore and Griffiths, *Phil. Trans. Roy. Soc.*, A, 244, No. 878, 113 (1951).

A NEW METHOD FOR THE PAPER CHROMATOGRAPHY OF OLIGOSACCHARIDES

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ALTHOUGH the application of paper chromatography to the separation and identification of bioses and higher saccharides was reported in 1948 by Partridge[1], and has since been used with advantage in numerous studies, the effectiveness of the method is still limited considerably by the low R_F values of these substances. In theory, the absolute distances separating components can be suitably increased by prolonging the irrigation time to several days; but, unless excessive care is taken, such a procedure often results in irregularities of the solvent front, and in any event is frequently too lengthy to be of use. Alternatively, the rate of movement of the oligosaccharides down the paper can be increased, as described by Hough, Jones and Wadman[2], and by Jeanes, Wise and Dimler[3]. The former workers ran the chromatograms at 37°, a procedure which is not altogether suitable for general use. Jeanes *et al.* increased the water content of the solvent and also introduced the multi-development technique; for example, with a solvent containing equal parts of fusel oil, pyridine and water, two to four developments, each of 22 hr., gave discrete spots of amylosaccharides ranging from maltose to the decaose.

We now report a new method, based on a different principle, by which considerable increases in R_F values (about eight-fold for disaccharides) may be effected; it involves the conversion of the oligosaccharides, on the chromatogram, into the corresponding N-benzyl glycosylamines, thus reducing their preference for the cellulose–water phase. Conditions suitable for the resolution of dextrins containing up to about ten sugar units have been determined; but there is no reason why, when the necessity arises, this range should not be extended by further modifications of the type described by Jones[2], Jeanes[3] and their co-workers.

After studies of the various factors involved, the following method was selected as being most suitable for general purposes: a spot of the sugar solution (2 μl.) is allowed to dry on the paper (Whatman No. 1), a spot (3 μl.) of a 10 per cent solution (w/v) of benzylamine in methanol is superimposed, and the paper is heated at 85° for 5 min., before being irrigated in the usual way with the upper phase of an *n*-butanol–ethanol–water–ammonia (40 : 10 : 49 : 1) mixture. After being dried, the paper is sprayed with a 0·25 per cent solution of ninhydrin in ethanol. The spots begin to appear within an hour, are fully developed after about 12 hr., and begin to fade after three days. The excess of benzylamine forms a band at the solvent front.

It is important that the sugar and benzylamine spots should be applied in the order given above; for best results only one spot of the sugar solution should be applied, otherwise succeeding spots tend to concentrate the sugar in a ring and the benzylamine is then less effective. Moderate amounts of impurities, such as mineral matter, organic acids, etc., do not interfere with the condensation. In view of the excessive amounts of benzylamine used, the initial spots of different test mixtures should not be closer than 3 cm. Although the N-benzyl glycosylamines stain with aniline hydrogen phthalate almost as well as the corresponding free sugars, the ninhydrin spray is more sensitive, and, moreover, does not detect the free sugar (*c.* 20 per cent) which remains after the reaction with benzylamine. About 5 μgm. of maltose or panose can be detected comfortably in an 18-hr. run; there does not appear to be any tendency for a major constituent in a sugar mixture to mask a minor one, provided that their R_F values differ sufficiently to permit the formation of discrete spots. It is desirable that the initial sugar solution should be free from impurities which, after development with an ammoniacal solvent, will stain with ninhydrin (for example, amino-acids, high concentrations of carboxylic acids); but if such impurities cannot be avoided, then their behaviour on a chromatogram must be known. A distinction between amino-acids and fairly strong spots of N-benzyl glycosylamines can be obtained by heating the sprayed paper for 2–3 min. at 85° after drying; under these conditions the glycosylamine derivatives, in contrast to the amino-acids, stain brown before turning to purple. Such heating causes no marked reduction in the time taken for N-benzyl glycosylamine spots to reach their maximum intensity. As evidence that the sugars do, in fact, move as N-benzyl glycosylamines, the spot obtained in the case of glucose has been shown to correspond to that of authentic N-benzyl glucosylamine[4] run in the same solvent (R_F *c.* 0·7).

Typical mixtures which can be resolved by the general method in 18 hr. are: (*a*) maltose and *iso*maltose; (*b*) *iso*maltotriose and panose; (*c*)

maltopentaose and maltohexaose (see also Fig. 1). The method is satisfactory for galactose, mannose, rhamnose and xylose (and presumably for oligosaccharides derived therefrom), but not for fructose. The N-benzyl glycosylamines of arabinose and ribose appear to be rather unstable under the conditions of the general method, but suitable modifications doubtless could be devised to meet these cases, if required.

For mixtures of disaccharides which give benzylamine derivatives with almost identical R_F values, it is usually better to employ an irrigating solvent containing less water than in the general method; for example, a distinction between *iso*maltose and gentiobiose can be observed readily in 28 hr. using the organic phase of a butanol–ethanol–water–ammonia (45 : 5 : 49 : 1) mixture (see Fig. 2).

With mixtures containing the higher oligosaccharides, improved results are obtained if the general method is modified in two ways: (*a*) by using a solvent of higher water content, namely, a mixture of butanol, ethanol, water and ammonia (40 : 12 : 20 : 1), and (*b*) by using a more efficient method of equilibration (see below). Under these conditions, the benzylamine derivatives of the higher homologues of maltose and laminaribiose have, respectively, the following approximate R_F values: tetraose, 0·36, 0·45; hexaose, 0·19, 0·32; octaose, 0·07, 0·21. Since laminarioctaose moves 8 cm. from the starting line in a 19-hr. run, it is clear that the method is capable of dealing with even higher saccharides, particularly if the running time is extended, or the water content of the solvent is increased still further. Within the range of saccharides examined, there seems to be little or no decrease in staining power, per reducing group, with increasing chain-length.

Thorough equilibration of the tank before the commencement of the run has a markedly beneficial effect on the R_F values of the slower-moving oligo-

Fig. 1. Chromatogram run for 18 hr. according to the general method. Besides glucose, spots are apparent corresponding to the oligosaccharides containing up to six glucose units in the 1 : 4-α series, and up to five in the 1 : 6-α and 1 : 3-β series

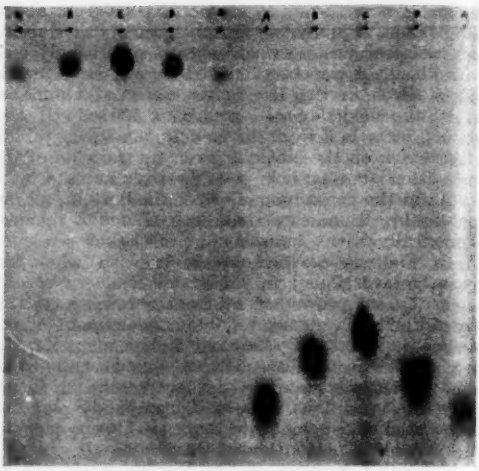

Fig. 2. *A*, maltose; *B*, *iso*maltose; *C*, gentiobiose; *D*, lactose. *Right:* Sugars treated with benzylamine and chromatogram sprayed with ninhydrin. *Left:* Identical sugar solutions run in the same solvent in the normal way and chromatogram sprayed with aniline hydrogen phthalate

saccharides. The usual method of equilibration, involving the use of trays of the solvent mixture in the bottom of the tank, takes at least 24 hr. and, during this time, glycosylamines are sometimes produced by interaction between ammonia vapour from the solvent and the N-benzyl glycosylamine spots. Since ammonia is essential in order to prevent hydrolysis of the N-benzyl glycosylamines, the following rapid method of equilibration was used. A blank sheet of filter paper was dipped into the irrigating solvent and suspended from a second trough in the tank. The solvent was introduced immediately into this trough, and the tank was sealed for 45 min., before the solvent was introduced through an orifice into the trough supporting the actual chromatogram. The degree of equilibration thus attained was better than that effected in 24 hr. in the usual way. Although this simple technique was designed primarily for use with the higher oligosaccharides, we find it beneficial also in the general method.

Following earlier theoretical considerations[5], Bate-Smith and Westall[6] deduced that $\Delta \log\left(\frac{1}{R_F} - 1\right)$ should be constant within a homologous series; they obtained good experimental confirmation with various phenolic compounds. Jeanes *et al.*[3] demonstrated later that the relationship, and also its approximation for low values of R_F, namely, $\Delta \log 1/R_F$, were true for a series of amylosaccharides. The benzylamine method enables these relationships to be tested over a wide range of R_F values. Preliminary studies with partially hydrolysed amylose and laminarin have shown good agreement, glucose excepted, with the relationship of Bate-Smith and Westall[6]; but, rather unexpectedly, with partially hydrolysed dextran, Jeanes's approximation holds better. A fuller examination of these and other homologous series of oligosaccharides, covering all types of glucosidic linkages, would enable a possible structure(s) for any oligosaccharide containing mixed glucosidic linkages to be assigned more accurately than in the past from the position of its spot relative to suitable markers. One advantage which would be gained thereby is

that, if a trisaccharide of this type were detected in the hydrolysis products of a polysaccharide, then the two different linkages of the triose would be proved to be adjacent in the polysaccharide itself.

In partial hydrolysates of the dextran synthesized by *Betacoccus arabinosaceous* (Birmingham strain) we have observed, *inter alia*, spots corresponding to a 1 : 3-biose and (more faintly) to a triose ; the position of the latter spot indicated that the triose contained a 1 : 6- and a 1 : 3-link. These observations suggested that the linkages at the branch points of this particular dextran molecule were of the 1 : 3-type, and not of the 1 : 4-type, as has been believed hitherto[7]. A full chemical analysis has confirmed that this is so[8].

Again, a partial hydrolysate of the polyglucosan of *Aspergillus niger* (strain 152), which was known already to contain 1 : 4- and 1 : 3-links in almost equal amounts[9], showed only one triose spot, the position of which indicated that it contained one of each of these linkages. Thus, it was highly probable that, in the polyglucosan, the 1 : 4- and 1 : 3-glucosidic bonds were arranged alternately ; confirmatory evidence of this has now been obtained by other methods[10].

The above observations are reported in the belief that they represent a real advance in the chromatography of oligosaccharides ; and, to the extent that paper chromatography is a useful preliminary to the isolation of crystalline reference compounds, that they will aid the determination of polysaccharide structures.

We are indebted to Prof. M. Stacey for his interest and advice, and to Dr. E. T. Dewar who kindly supplied the laminarin employed. [Sept. 29.

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PATTERN DISCRIMINATION AND THE VISUAL CORTEX

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DURING recent years attempts have been made to explain the organization of the cerebral cortex in terms of electronic computing machines. Comparisons have been made with two-way switches, regenerative storage systems and cathode ray tube scanning-systems ; yet none of these analogies has met with general acceptance, nor have they led to testable hypotheses.

We have made an attempt to examine some of the problems associated with pattern discrimination and the organization of the visual cortex by means of two approaches, each of which is fundamentally statistical. On one hand, some of the elements of the visual cortex have been described in a statistical manner (D. A. S.) while, on the other hand, the organization of a machine operating on a probability basis has been explored (A. M. U.). It is suggested that a valuable analogy exists between the two methods of study. Some relations between them are beginning to emerge, and already there has been a surprising measure of agreement between hypotheses suggested by the theory of the machine and the experimental observations of cortical structure.

There is reason to believe that many of the complexities of the cerebral cortex are due to an organization that is fundamentally of a statistical nature and the parameters of which can only be described in terms of probabilities. One of the obstacles to the formulation of adequate hypotheses for many branches of biology has been the language and mathematics which have been used in attempts to frame these hypotheses ; consequently, some of the concepts that we introduce will be strange to biologists. Nevertheless, we feel that the effort to master this approach will be amply repaid.

First of all, the finer branches of the axons running from the thalamus to the primary sensory areas of the cerebral cortex end in an apparently random manner among the surrounding cells and their dendrites. Quantitative study of the lengths of the dendritic processes and their branches shows that there is no simple law relating these lengths to the position of the cell or the size of the perikaryon.

With this background, one of us (A. M. U.), working in the field of computer design, has proposed definitions of the word 'pattern' in terms of set theory, and of 'measure of pattern difference'. These definitions have led to the design of an efficient machine with random connexions between its units and the inputs, and with the ability to measure differences between a representation and a constantly changing statistical description of past representations.

By a 'representation' is meant a set of physical quantities internal to a machine, which are determined by an external physical configuration and may be called attributes of it ; each attribute will have a measure, which may be continuous or discrete. By a 'pattern' is meant a subset of such measures. A machine for comparing a present representation with a past ensemble of representations, member by member, requires a storage capacity that must grow with the ensemble, and each comparison leads only to a binary statement of identity or difference. If, on the other hand, a statistical method of describing the ensemble of representations is used, whereby the ensemble is specified by the relative frequencies with which the different sets of attributes have occurred in the past (or the probabilities that the members of the 'given' ensemble possess certain sets of attributes), and if the comparison is made only with this system, then a constant storage capacity is all that is required. For example, if there are n input quantities (attributes) and each has s possible discrete measures, the number of different possible representations can be shown to be $(1 + s)^n$; this is the fixed number of descriptive probabilities that must be stored, regardless of the number and type of past representations.

The simplest possible machine of this nature must employ the simplest possible measure for which s is unity. In this case, either a proposition of the form

'the configuration A possesses the property j' is made, or no proposition is made at all. This measure will be called unitary, in contrast with binary measure in which an additional proposition of the form 'the configuration A does not possess the property j' is made. The input, therefore, must possess two states; if it is active, a proposition is made, and if it is inactive, no proposition is made.

An example of the kind of mechanism that could provide an input of this unitary nature would be a threshold-operated detector which could be in one of only two states. The detector would be in an active state if, say, a chemical concentration or a packet of radiant energy exceeded a certain value; otherwise the detector would be inactive. There must be no varying degree of activity in any one input channel to the machine. In consequence, for detectors of a different nature, it would be necessary to interpose a coding system between them and a machine of the type which has been described.

Using this unitary measure, a complete non-redundant statistical description of an ensemble of representations consists of the joint probabilities of occurrence of all possible sets of attributes. It is therefore necessary to have units capable of counting and storing these probabilities; and the units must be connected to the inputs in all possible ways. This can be achieved precisely by random connexions between the input points and the units of the machine; it can be shown that if the chance of any unit being connected to any particular input is $\frac{1}{2}$, each unit will be replicated about the same number of times. Other laws describing the probabilities of connexions will lead to other population distributions.

In order to define a measure of pattern difference between a present representation and a past ensemble in respect of a set of attributes, the following axiom is laid down: if the set can be separated into two subsets with *a priori* independence, the pattern difference in respect of the total set is the sum of the pattern differences in respect of the two subsets. From this it can be shown that the only possible measure of pattern difference is the negative logarithm of the *a priori* probability of the set; if the set does not occur in the present representation, there is no measure of pattern difference. Probabilities must therefore be computed in the units on a negative logarithmic scale.

For a past ensemble occurring as a sequence in time, each unit must have two properties: it must possess some quantity which grows approximately logarithmically with time, and the act of counting must consist in the destruction of some of this quantity. Different mathematical laws of growth and destruction lead precisely to different weighting functions of past events. The act of counting must occur only if all the connected inputs are in the active state caused by occurrence of the corresponding attributes.

The machine can be extended to measure a difference in respect of a pattern, even if some of its attributes have not occurred; it can be shown that the measure must be the negative logarithm of the conditional probability of the set of attributes.

Conditional probabilities can be computed in the following manner. Consider attributes j, k and l; there will be units storing $-\log p(jkl)$ and $-\log p(jk)$, the negative logarithms of the probabilities, in the past, of the sets (jkl) and (jk). If (jk) occurs, then the conditional probability of the set (jkl) is $p(jkl)/p(jk)$; so that on a negative logarithmic scale the (jkl) unit should contain $-\log p(jkl) - (-\log p(jk))$. This can be achieved if the momentary decrease in the (jk) unit, from $-\log p(jk)$ to zero, is communicated to the (jkl) unit. This effect has been called supercontrol; it leads to precise laws defining the connective function between units; these laws are different from those required between inputs and units for counting purposes. An electromechanical model of the basic unit has been built embodying the principles described and which possesses all the necessary properties of counting, storing and interconnexion.

Returning to the problem of random connexions, the simple statement that the probability of connexion is $\frac{1}{2}$ cannot lead to a knowledge of the position of units in relation to a set of inputs; this will be determined by the manner in which the probability of connexion depends on the position of the input relative to the unit. It can be said that there is a connective probability field surrounding a unit; from the form of this field it is possible to calculate the distribution of units which are directly connected to inputs for the purpose of computing unconditional probabilities. Supercontrol employing interconnexions between units leads to the concept of an indirect connective probability field. For the two forms of control to be effective, the direct and indirect fields must be of approximately the same form; it can be shown that this is met if they fall off exponentially with distance from the unit.

It is possible to define the probability of connexion between an incoming axon and cortical dendrites according to our limited knowledge of the physiology of the connective process and the morphology of the cell. It has been shown experimentally (D. A. S.) that this direct connective probability field does, in fact, fall off exponentially with distance from the perikaryon. This is equally true of the basal dendrites of the pyramidal cells.

To calculate the actual numbers of connected units a second factor is required, the packing density of the perikarya; this has also been determined. It has therefore been possible to predict the population distribution of cells connected to different numbers of afferent fibres.

Finally, we wish to stress the fundamental importance of the decisions: (*a*) to base the theory on the statistical description of an ensemble; (*b*) to adopt a continuous measure of pattern difference; and (*c*) to employ a unitary measure of attributes. The binary measure of pattern difference leads to binary machines employing the gating principle; such a pattern machine can handle two-valued logic, but it can compare only single items, not ensembles. The result of the comparison is of the form 'A differs from B' or 'A does not differ from B'. The continuous measure leads to statistical machines employing the analogue principle; such pattern machines can compare two ensembles, or a single item with an ensemble. The result of the comparison is continuous and has the form 'Item A differs from ensemble C by more than does item B'.

A full account of the mathematical concepts involved and a detailed description of the application of the theory to specific problems will appear elsewhere.

We wish to thank Prof. J. Z. Young for his encouragement and valuable criticism of this work. Acknowledgment is made by one of us (A. M. U.) to the Chief Scientist of the Ministry of Supply for permission to publish this paper. [Nov. 20.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Investigation of the Cœlacanth

IT was my privilege to carry out detailed investigations on the first Cœlacanth, and to have discovered what appears to be the area where those fishes still live.

The recent Comoran Cœlacanth, while mutilated more than was at first realized, nevertheless retains most of the soft parts, including the abdominal viscera. This extends enormously the scope of the investigational work that may be carried out on the specimen. There will be still more that can be done only on parts, exudates, and secretions from an untreated fresh specimen, which it is hoped to seek before very long.

It is in keeping with the importance and scope of the investigations on all parts of this fish that they should be assigned to leading experts in the field in which they fall. I have advised the South African Council for Scientific and Industrial Research, and have requested the Council's approval of and co-operation in this matter.

Application to be included in this scheme should be sent either to the South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, or to me personally at Rhodes University, Grahamstown. While every possible facility will be granted to selected visiting specialists, it should be noted that there is no possibility of financial aid from this end.

The ownership of the next specimen or specimens is of less importance than their proper preservation for scientific purposes. As certain organs and body fluids require special treatment and preservation, it is intended to compile a set of special instructions to be issued to those in areas where it is possible that a fresh Cœlacanth may be obtained. It will be appreciated if those interested will kindly furnish detailed special instructions composed in language as simple as possible, giving full directions and not only the names, but also the actual composition of any materials to be employed.

Since there is a hope that more Cœlacanths may be found at the Comoro Islands, it is desirable that all such materials should be available there.

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Plastic Properties of Coking Coals

THE processes which take place when a coking coal is turned into coke by heating in the absence of air are very complex and only partly understood, though they have been studied for many years[1,2]. We have made a renewed approach to the problem, and have evolved for guidance an elementary theory applicable in the temperature-range within which coking coals show plastic properties. Supporting experimental evidence is described below.

It is widely accepted[1] that a coking coal at temperatures of the order of 300° C. and higher shows plastic properties, the word 'plastic' being used here in a general sense; and there is evidence that it behaves as a liquid having a normal viscosity–temperature relationship[3]. At temperatures approaching 400° C., this liquid is subject to thermal decomposition and changes into a gas and an infusible solid. We assume this change to take place according to the laws governing first-order chemical reactions, so that if at time $T = 0$ there exists a mass m_0 of coal in the liquid state, at a later time $T = \tau$ there will remain a mass :

$$m_\tau = m_0 \exp -k\tau,$$

where k is the velocity constant of the decomposition reaction at the temperature of the decomposition; and at any later time $T = \tau + t$, there will be :

$$m_{\tau+t} = m_0 \exp -k(\tau+t) = m_\tau \exp -kt. \quad (1)$$

The time $T = 0$ can never be experimentally realized, as some decomposition must take place in the period of heating to the required temperature, which for reasons of fundamental and experimental limitation cannot be made infinitely short. The time $T = \tau$ is taken to be the time when the predetermined temperature has been reached.

As the solid product of decomposition accumulates, the viscosity of the liquid/solid mixture will rise. We assume a relationship of the form :

$$\bar{\eta} = \eta(1 + \lambda c),$$

where λ is a constant later shown to be equal to, or not far from, unity, η is the viscosity of the mixture before the concentration of solid matter is inc eased by c, after which it becomes $\bar{\eta}$. (A fixed value of λ cannot be assumed, *a priori*, to apply over a long period of time, but it can be shown that it approaches constancy over periods which are not infinitesimal. Idealized extreme cases of solid suspensions and analogous systems have been studied by G. I. Taylor[4] and A. Einstein[5].) It follows that

$$\eta_{\tau+t} = \eta_\tau \left(1 + \lambda \frac{m_\tau - m_{\tau+t}}{m_{\tau+t}}\right); \quad (2)$$

and substituting from equation (1), we have :

$$\eta_{\tau+t} = \eta_\tau (1 + \lambda \exp kt - \lambda),$$

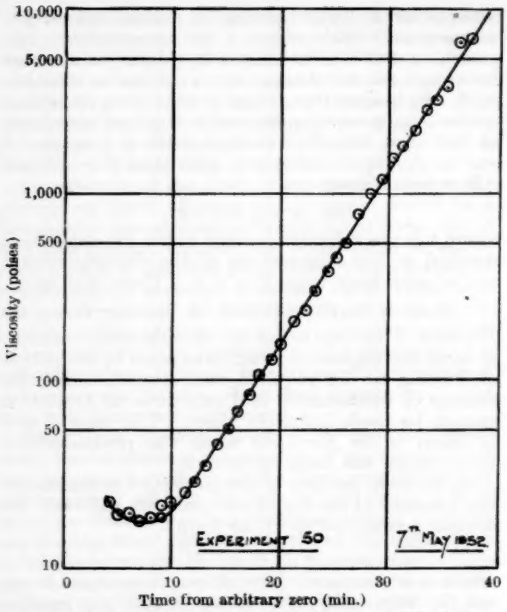
so that :

$$\frac{d}{dt}(\log \eta_{\tau+t}) = \frac{\lambda k \exp kt}{1+\lambda \exp kt - \lambda} = \frac{\lambda k}{(1-\lambda)\exp(-kt)+\lambda}. \quad (3)$$

This equation makes the following statements concerning the slope of the graph of $\log \eta$ against t: (i) for $t \to 0$, the slope tends to λk; (ii) for $t \to \infty$, the slope tends to k. Thus, as t increases, the slope changes from λk to k.

The predictions of the theory were checked by measuring the viscosity of four different coals at various temperatures using an apparatus developed by Gieseler[6] and other workers[7]. A stirrer is embedded in compressed powdered coal in a crucible. A torque is applied to the stirrer which makes it rotate when the coal softens on heating. The viscosity of the coal is inversely proportional to the rate of revolution of the stirrer. In the past, the apparatus has been used for observing the viscosity changes with rising temperature, but there is no difficulty in adapting it to work at constant temperature.

The graph shows the result of a typical experiment. A linear relationship between $\log \eta$ and t is clearly shown. The precision of the experiment is such that a slight curvature would not be detected. Exact linearity would imply $\lambda = 1$ (see equation 3), so that the slopes give the reaction velocity directly. The graphs obtained permit the statement that λ is a



Results of a typical experiment on 'Manvers coal' at 414 ±½° C.; the slope is 0·094 min.$^{-1}$

constant in the range $0{\cdot}8 \leqslant \lambda \leqslant 1{\cdot}2$. The value of λ does not affect the calculation below.

Experiments have been carried out at a number of temperatures, for each coal, so that the values of λk can be used to find the activation energy of the carbonization process, using Arrhenius's equation:

$$\log k = \frac{-E}{RT} + \text{constant},$$

where E is the activation energy, R the gas constant, and T the absolute temperature. Graphs of $\log k$ against $1/T$ gave straight lines for each of the coals examined.

The table gives details of the four coals used, together with the activation energies found. It is interesting to note that although these coals differ widely in their coking properties, assessed by conventional criteria, all the activation energies are near 50 kcal./mole, which has been quoted as the energy required to break the carbon–carbon bond in the thermal decomposition of mineral oils[9].

Details of Coals Used

Coal		Volatile matter† (dry ash-free) %	Agglutinating value‡	Temperature-range over which E is determined (° C.)	Activation energy (kcal./mole)
Name	Type*				
"Maritime"	301	24·6	26 : 1	419–448	52·7±2·8
"Manvers"	502	37·6	23 : 1	406–427	48·2±2·4
"Blackwell" (blend)§	602/401	38·0	20 : 1	402–422	54·2±2·2
"Grassmoor"	702	40·0	17 : 1	405–426	47·3±1·2

* Coal Survey Classification, according to: Survey Paper No. 58, "Rapid Survey of Coal Reserves" (Fuel Research Division, D.S.I.R., H.M.S.O., 1946).
† According to B.S.1016.
‡ According to B.S.705.
§ Of which 25 per cent has 31·8 per cent dry ash-free volatile matter content and 75 per cent has 41·0 per cent dry ash-free volatile matter content.

The values we have obtained agree well with those of van Krevelen and co-workers[10], who used a very different method on a series of broadly similar coals.

This work is being continued at this Establishment, along the lines indicated, and is published by permission of the Director-General, Scientific Department, National Coal Board. A fuller treatment will be published elsewhere.

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Sept. 15.

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Selenium Hexafluoride: Dielectric Strength and some Chemical Properties

The physical and chemical properties of selenium hexafluoride have received little investigation[1,2]. We have prepared selenium hexafluoride by reaction of the elements at 300° C. in a copper tube, and found that, provided steps are taken to return selenium tetrafluoride (boiling point, 106° C.) to the reaction zone, a yield of more than 90 per cent selenium hexafluoride is readily obtained. The gas was condensed in a trap cooled to − 160° C. and afterwards sublimed into an aspirator. The greater part of the small amount of selenium tetrafluoride collected remained in the trap after the selenium hexafluoride had sublimed. The product was scrubbed with 10 per cent sodium hydroxide solution, condensed in liquid air, and transferred to an evacuated steel cylinder cooled in 'Drikold'.

The vapour density of a sample of the purified gas, dried by sublimation *in vacuo* from a trap cooled to − 80° C., was determined by direct weighing and the molecular weight found to be 192·6 ± 1 (theoretical value, 192·96).

Hokhberg and Sandberg[2] have reported the dielectric strength of selenium hexafluoride to be nearly twice that of sulphur hexafluoride, giving the ratio 4·63 : 2·49 : 1 for the relative dielectric strengths of selenium hexafluoride, sulphur hexafluoride and air. Their measurements were carried out using two Rogovsky electrodes of 32 mm. diameter spaced at 2–8 mm. The maximum value of pressure × gap was 220 mm. mercury × cm., and the results were extrapolated to a value of 1 cm. at 1 atmosphere pressure. They make no mention of the method of preparation or of the purity of the gases tested.

The breakdown potential between two half-inch diameter brass spheres has been measured in selenium hexafluoride prepared as above, in sulphur hexafluoride containing not more than 41 p.p.m. of

RELATIVE BREAKDOWN VOLTAGES IN SELENIUM HEXAFLUORIDE, SULPHUR HEXAFLUORIDE AND AIR

Pressure × gap mm. Hg. × cm.	Relative breakdown voltage		
	SeF_6	SF_6	Air
50	1·80	1·75	1
100	2·10	2·00	1
150	2·40	2·20	1
200	2·50	2·30	1
250	2·65	2·40	1
300	2·70	2·40	1
350	2·75	2·40	1

disulphur decafluoride and 12 p.p.m. of sulphur tetrafluoride, and in dry air. The relative breakdown voltages obtained using gaps of 0·05–8·6 mm. and pressures of ½, 1, 1½ and 2 atmospheres are shown in the accompanying table. Extrapolation of the results to a gap of 1 cm. at 1 atmosphere pressure indicates that the relative dielectric strengths of selenium hexafluoride to air and of sulphur hexafluoride to air are not greater than 2·9 : 1 and 2·4 : 1 respectively.

We have found selenium hexafluoride to be slightly soluble in alcohol and acetone, insoluble in 5 per cent aqueous sodium hydroxide solution, but soluble in 10 per cent alcoholic sodium hydroxide solution. It reacts slowly with mercury, forming mercurous fluoride, and reacts readily with a solution of sodium iodide in acetone :

$$SeF_6 + 6NaI \rightarrow Se + 6NaF + 3I_2.$$

No change in volume occurs after heating selenium hexafluoride to 500° C. for 10 min. in 'Pyrex' glass. At 700° C., reaction with the glass occurs.

We wish to acknowledge our indebtedness to Mr. G. H. F. Seiflow and Mr. J. Adams, who carried out the electrical measurements.

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Sept. 17.

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Thermal Degradation of Polystyrene

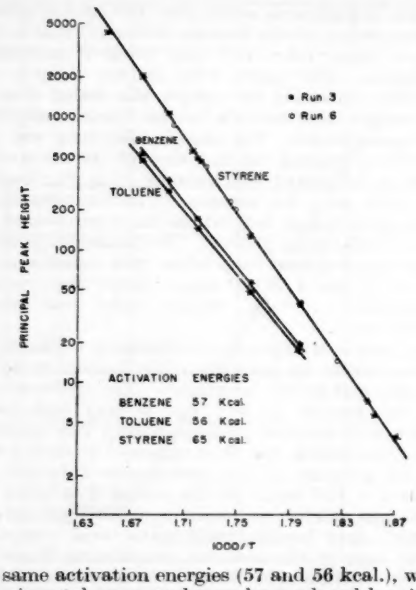
THE degradation of polymers may be elucidated by various approaches ; one of the more accessible routes is a study of the volatile degradation products. Grassie and Melville[1] measured the pressure of volatilized monomer (having determined the identity of the gas by other means) from heated polymethyl methacrylate in a continuously pumped system with a constriction limiting the pumping speed to a constant value. The measured pressure was directly proportional to the rate of production of monomer. This method has been modified by using a mass spectrometer instead of a Pirani gauge. The advantages of the mass spectrometer as the pressure gauge are : (*a*) it can analyse the gas produced ; (*b*) it can measure each product independently ; (*c*) it has great sensitivity.

Twenty-five milligrams of thermally polymerized styrene prepared by Dr. F. R. Mayo of this laboratory was deposited as a film over 150 cm.² of quartz by evaporation of the benzene solvent. This would leave a layer $1{\cdot}6 \times 10^{-4}$ cm. thick if uniformly distributed. The quartz tube (20 cm. long, 4 cm. diameter) containing the sample was sealed directly to the sample inlet tube of a General Electric analytical mass spectrometer. The sample inlet tube was the constriction limiting the flow through the ion source. It had a calculated conductance of approximately 0·012 litre sec.$^{-1}$ for styrene. The conductance of the pumping system beyond the ion source was of the order of 1,000 times greater. The maximum pressure in the spectrometer tube when rate measurements were made was 2×10^{-7} mm. ; hence the pressure of monomer in the sample tube was about 2×10^{-4} mm.

The sample was given a preliminary degassing to remove solvent by pumping while heating at 80° C. for 4 hr. and at 30° overnight. The spectrometer, with the sample at 30°, had a very high background, with benzene predominating. The temperature of the sample was then increased at such a rate that the pressure in the spectrometer tube did not exceed 1×10^{-6} mm. At the end of five hours the sample was at 110°, and benzene, methyl*cyclo*hexane, toluene, ethyl benzene and acetic acid comprised 95 per cent of the material evaporating from the sample. Within nine hours a temperature of 145° was reached, and acetic acid predominated in the volatilized materials. After sixteen hours at 145°, the rate of production of volatile materials dropped, permitting the sample to be heated to 210° before large amounts of acetic acid limited the rate of heating. A temperature of 220° was reached in three additional hours. Small amounts of styrene were then observed, along with other materials, the acetic acid having decreased. The temperature was increased by small steps which brought out more acetic acid at the beginning of the next three or four increments ; benzene and toluene were also produced. A temperature of 310° was finally reached. At this temperature the polymer was decomposing, chiefly to styrene, benzene and toluene, but the rates of evolution decreased with time at any one temperature. The sample was then left at 230° for about seventy hours ; at the end of this period there was no measurable evolution of gas. All the results noted up to this point were ascribed to adsorbed or dissolved impurities, or odd configurations present in small amounts. The total amount of material volatilized is estimated as less than 1 per cent of the sample. The persistence of the solvent, benzene, under conditions where 'molecular distillation' would remove it in an extremely short time, indicates another rate-limiting process. This indicated a phenomenon to be considered in other investigations of this kind. The presence of acetic acid and methyl*cyclo*hexane is unexplained. The early evolution of styrene (at 220°) may have been due to desorption of unreacted monomer or scission of loosely bound monomer.

Subsequent heating of the sample from 230° to the temperature-range 260°–330° C. at intervals extending over a period of ten days showed the rates of evolution of styrene, benzene and toluene to be functions of temperature only. This is believed to be decomposition of the polymer. A plot of principal peak heights for these three materials against the reciprocal of the temperature is reproduced herewith.

From the graph, the activation energies for the production of the various substances have been derived. It is seen that benzene and toluene have



the same activation energies (57 and 56 kcal.), within experimental error, and may be produced by similar mechanisms. The styrene has a distinctly greater activation energy (65 kcal.) and must be accounted for in another way.

The rate of production of styrene may be calculated if the signal height for a given rate of flow can be established[2]. This was determined, and it was found that a rate of $1{\cdot}0 \times 10^{-4}$ μlit./sec. gave a peak height of 960 units. Hence at 330°, $7{\cdot}0 \times 10^{-3}$ per cent of the sample will decompose per minute to styrene. Extrapolations of Madorsky's results[3] for higher temperatures would indicate a maximum rate of $4{\cdot}0 \times 10^{-2}$ per cent per min. at 330°. It should be pointed out that the results described here were obtained with less than 1 per cent of the total sample degraded, and the results were obtained in the temperature-range 260°–330°. Madorsky, working in the range 335°–365°, degraded a large fraction of the sample; hence, our results are not expected to be comparable. His value of 58 kcal. for the initial activation energy was deduced from measurements of loss of weight of the sample, as was the value of 44·7 found by Jellinek[4]. In the cases cited, the weights of volatilized materials were summed, instead of measuring the rate of volatilization of each substance.

In addition to styrene, benzene and toluene, small amounts of other substances were observed, the dimer of styrene being next in abundance. Higher temperatures would be required to get reliable values for the activation energies of these other materials. The very high molecular weight materials reported by Madorsky were not observed under these conditions of degradation and measurement.

The simpler case of polymethylmethacrylate was studied in the temperature-range 170°–210°, and an activation energy of $29{\cdot}5 \pm 1{\cdot}0$ kcal. was found for the production of the monomer, essentially in agreement with 31·0 kcal. found by Grassie and Melville[1]. The problem of removing solvent and other impurities were more acute in the case of methylmethacrylate; however, when they were removed, the monomer alone was produced.

The investigation is being extended to other systems, and detailed results and interpretations will be described elsewhere.

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Oct. 27.

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Interaction of Manganous Ions with Enolase

Many enzymes require the presence of metal ions for activity[1]. Kinetic studies on such systems indicate the existence of an equilibrium between the enzyme protein, the activating metal ion and a complex between metal ion and enzyme. By assuming the complex to be the only species catalytically active, a hypothetical dissociation constant can be determined from activity measurements. Considerations of this kind have led Smith[2] to formulate a theory of peptidase action according to which the metal ion acts as a binding group bringing enzyme and substrate together. Already in 1942, the same type of mechanism was suggested by Warburg and Christian[3] for the activation of enolase by magnesium, manganous and zinc ions. Since, however, no direct measurements of the interaction of activating metal ions with well-characterized enzyme preparations have been published, the present study was undertaken.

Enolase was purified by the method of Warburg and Christian[3]. These authors only investigated the activation by magnesium ions in detail, but the present work was extended to include the other activating ions. Fig. 1 shows the activity[3] of the enzyme as a function of the concentration of manganous ions measured in a 0·04-*M* phosphate buffer, *p*H 6·8. Employing the conventions of Warburg and Christian[3], the hypothetical dissociation constant of the enolase–manganous ion complex was calculated to be $2{\cdot}5 \times 10^{-5}$ mole/l. under the conditions used.

The interaction of manganous ions with enolase was also studied by the equilibrium dialysis technique[4]. Fig. 2 gives the average number of manganous ions bound per molecule of enzyme in 0·025 *M* phosphate buffer, at *p*H 6·8 and + 4°, as a function of the concentration of free manganous ions. The experimental points are too few to permit a detailed mathematical analysis, but they indicate that, in the range of concentration studied, the manganous ions

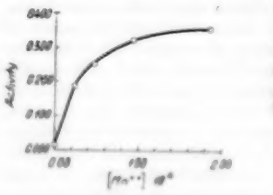

Fig. 1 Fig. 2

Fig. 1. Influence of the concentration of manganous ions on the activity (arbitrary units) of enolase in 0·04 *M* phosphate buffer, *p*H 6·8

Fig. 2. Effect of the concentration of free manganous ions on the number bound by enolase in 0·025 *M* phosphate buffer, *p*H 6·8, at + 4°

interact with four groups of the enolase molecule, the overall dissociation constant being about 2×10^{-5} mole/l., a value of the same order of magnitude as that calculated from the activity measurements.

If it is assumed that the four binding groups are identical and do not interact, the logarithm of the first association constant can be calculated and is 5·3. Thus, the interaction of manganous ions with enolase is stronger than that demonstrated with any amino-acid or simple peptide[5-7]. It is of interest to note that the enolase molecule contains eight sulphur atoms[3], since Cohn *et al.*[8] have recently suggested that cystine may furnish the complex-forming group in metal-activated enzymes.

The work described in the present communication is being extended and a detailed report will be published elsewhere.

I wish to thank Prof. Arne Tiselius for his interest in this investigation.

Note added in proof. Experiments on the activation of enolase by zinc ions, carried out since the above communication was submitted for publication, demonstrated a fall in activity at high metal ion concentrations. This led to a re-investigation of the activation by manganous ions, which showed that the data are more correctly interpreted by assuming two types of interaction between manganous ions and enolase, one giving an active complex and the other resulting in inhibition. If this inhibitory effect is taken into account, the hypothetical dissociation constant of the active complex is found to be $4 \cdot 4 \times 10^{-5}$ mole/l. (as compared with $2 \cdot 5 \times 10^{-5}$ mole/l. above), while that of the inactive complex is 2×10^{-3} mole/l.

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A Biophysical Test for Aldohexoses

I have observed that some sugars inhibit the flocculation of bottom-fermentation brewer's yeast in tap water, whereas others do not.

Sugars which inhibit flocculation	Sugars not inhibiting flocculation
Glucose	Fructose
Mannose	Galactose
Maltose	Lactose
Sucrose (after interaction for some time)	Xylose
	Arabinose
	Dextran, etc.

The flocculation is thus inhibited by aldohexoses. This fact can be used for a quick test for glucose in the presence of fructose. About 30 mgm. of freeze-dried brewer's yeast were suspended in 5 ml. of tap water. When held at rest, the yeast flocculates, and is precipitated within one minute. On addition of an equal volume of the solution under examination, the presence of the above aldohexoses is indicated by the fact that the yeast suspension remains stable for a longer time (some hours). The influence is distinct up to a sugar concentration of 0·1 per cent.

The *p*H of the solution should be kept in the range 4–7, and the temperature above 25° C. As a condition for flocculation is the presence of calcium or magnesium salts in the medium, anions giving undissociated salts with these metals, such as oxalate, fluoride, phosphate and carbonate, should be avoided.

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Dynamic Potentials of Freshly Formed Liquid Surfaces

As a basis for the study of the adsorption of a surface-active solute to a fresh liquid surface, it is necessary to establish with accuracy the changes in the physical properties of the surface which occur immediately after its formation, and throughout the adsorption process. Two important properties, which undergo considerable change as adsorption proceeds, are the surface tension and the surface potential. We have recently observed that the surface potential of aqueous solutions of many long-chain compounds, at the instant when adsorption is complete, differs widely from the ultimate equilibrium value. The changes in potential following establishment of concentration equilibrium between surface and bulk solution are comparable in magnitude with those occurring during adsorption, and erroneous deductions may result from the assumption that dynamic surface tensions and potentials change in a similar manner with age of surface.

Measurements of the rate of change of surface tension in aqueous solutions of straight and branched-chain alcohols[1] have shown that the surface tension of such solutions is determined primarily by surface concentration of solute, and is little influenced by molecular orientation in the surface. Changes in dynamic surface tension therefore provide a satisfactory means of following the development of an adsorbed film; when concentration equilibrium is established, no further appreciable change in tension occurs.

Curves *A* and *B* in the graph compare the change in surface tension and potential respectively for a 0·00045 per cent aqueous solution of decyl alcohol at 15°. Whereas tension is constant after one minute, the potential shows a considerable rise after adsorption is complete. In interpreting these effects, we consider that adsorbing molecules of solute arrive at the surface in a disorientated state, and that the continual arrival of solute molecules maintains this disorientation throughout the adsorption process. Unlike tension, the surface potential is influenced greatly by surface orientation as well as by surface concentration; the potential of the surface when adsorption is complete is therefore characteristic of the disorientated film. The general use of the well-known expression $\Delta V = 4\pi n\mu$ in surface potential studies implies that the decrease in the air–water contact potential (ΔV) is brought about by the solute only. However, it seems probable that the potential changes which follow adsorption are greater than can be attributed entirely to variations in the effective dipole moment μ; it is therefore considered that water as well as solute molecules are disorientated by adsorption to fresh surfaces.

When the disturbing effect of adsorption is no longer operative, the film can become rearranged to

At the tropopause there is generally an increase in the magnitude of the rate of fall (lapse-rate) of frost point with height; but this increase usually holds over a shallow layer only, and higher up the lapse-rate returns to the value it had in the upper troposphere. The increase in lapse-rate of frost point at the tropopause is most marked when there is an increase of air temperature with height there. Such an arrangement is characteristic of the tropopause above depressions and is believed to occur because the tropopause moves downwards over a depression. The subsidence of the air of the lower stratosphere necessarily tends to produce an inversion of temperature and a reduction of frost point. When the tropopause is marked in the vertical temperature curve by a reduced lapse-rate and not an inversion, the lapse-rate of frost point shows no tendency to increase there. This is characteristic of anticyclones and occurs because above them the tropopause is lifted up.

The humidity observations are analysed also for variation with season and air mass and the changes which occur on passing through a frontal surface.

The height attainable by the aircraft used for making the observations was not sufficient to enable them to climb into the stratosphere when the tropopause was above about 41,000 ft., and the results have some bias towards low tropopause. It is to be hoped that measurements of humidity to greater heights in the stratosphere will become possible in the future on a routine basis. The Americans Barrett and Herndon have flown an automatic frost-point hygrometer to 100,000 ft. below a very large plastic balloon; but their apparatus (Compendium of Meteorology, American Meteorological Society, p. 1220; 1951) weighed 46 lb. Routine flights with balloon-carried apparatus must await the development of a lighter instrument.

SOCIAL SECURITY AND UNEMPLOYMENT IN LANCASHIRE

UNDER the title "Social Security and Unemployment in Lancashire", Political and Economic Planning has issued a useful broadsheet (No. 349; December 1, 1952) analysing the effects of unemployment on the working of the more comprehensive social security measures now in existence. The information was sought particularly from the cotton towns, and, although the survey is too limited to throw light on the adequacy of benefit and assistance payments, it confirmed the conclusion reached in an earlier broadsheet that actual patterns of expenditure by poorer families differ widely from that accepted as the basis of social security payments. Families appear to draw extensively on savings, and, failing these, economize on food and fuel to maintain certain types of expenditure, including even entertainment, as long as possible. The survey has shown that relatively few of the unemployed in Lancashire have applied for national assistance. This is partly due to ignorance or misunderstanding about the regulations, especially those concerning house ownership and the amount of savings which are to be disregarded in assessing need. Something less than half of those who would qualify for assistance seem ready to ask for it.

While on the whole the machinery of the scheme appears to have been put into motion quickly and smoothly, and regulations too have been administered in the spirit of the new Acts, the survey has shown that many people do not qualify for benefit, or qualify only for less than the standard amount. Most of the former are married women, and P E P makes the point that, when married women have to stay at home from time to time for such reasons as looking after their children or an invalid dependant, there is a strong case for relaxing the contribution conditions so as to enable more married women to draw benefit, either by crediting them with insurance contributions or by permitting them to continue contributions as if they were still in employment. Workers with secondary, part-time occupations are also in an anomalous position, and P E P suggests that the Ministry of National Insurance should review the regulations concerning subsidiary earnings in the light of recent experiences in Lancashire.

The evidence collected in Lancashire must obviously be interpreted with great caution for other areas; and P E P directs attention to the difficulty in making precise judgments about the working of the social services in Lancashire, because of the gaps in information which exist and the different methods by which the various official statistics are collected and presented. If for good reasons unemployment and national insurance statistics cannot be made comparable, it suggests that sample inquiries in circumstances such as those in Lancashire during recent months would provide evidence of material value to administrators and others concerned with the social services as well as to research workers.

BREEDING BEHAVIOUR OF THE SWIFT

THE breeding biology of the swift (*Apus apus*) has been studied by David and Elizabeth Lack (*British Birds*, **44**, No. 6; June 1952). The first observations were made in 1946 on birds nesting in holes in thatched roofs in villages near Oxford; attempts were made later to induce the birds to breed in nest boxes. For many years swifts had nested in the ventilators in the tower in the Museum of Oxford and, in 1948, platforms were erected inside the tower and ventilators were replaced by nest boxes to which glass backs were fitted. The observers could now sit in semi-darkness a few inches from the birds, watching against the light from their entrance holes without causing them any disturbance. The paper describes the behaviour recorded.

Most adult swifts show little fear in their boxes, presumably owing to lack of natural enemies at the nest. There is, however, great individual variation. Some were extremely tame from the start and were not at all disturbed when, in weighing experiments, the eggs or young under them were removed and later replaced. Others at first left the box if a hand were inserted, but became tame through repeated handling. Some fiercely attacked an inserted hand with their claws, and displayed if noises were heard outside the box or objects seen near the glass.

The observations showed that each year about twenty pairs laid eggs, and several non-breeding pairs, possibly in their first year, occupied other boxes. The adults arrived in spring and departed in summer over about three weeks, the two members of each pair usually arriving and departing separately. Each pair normally rested in their boxes throughout the summer.

Adults were seen to visit the boxes at any hour of the day but especially around 7.30 a.m. and 6 p.m., sometimes sheltering in the boxes in rain. In fine weather single individuals or small parties might fly up to and brush against the boxes and were treated as strangers by the pairs. When another swift entered the box it was often treated with insipient threat display. If it were the bird's own mate, the display quickly gave place to mutual preening; if it were a stranger, a fight sometimes followed. Little preliminary display took place before coitus, which occurred in the boxes.

Nest building was observed to start on the day that the pair was formed and continued until the end of incubation, the material being stuck down with saliva. Non-breeders were observed to build throughout the summer. If a clutch of eggs were lost for any reason a repeat clutch sometimes followed. Part or the whole of the clutch was sometimes ejected, the ejected eggs being sometimes fertile. The reason for ejection is still obscure.

Parent birds took an equal share in incubation, the time of each sitting varying from 2 to 345 minutes; the eggs were sometimes left uncovered during the day for periods of up to 6½ hours. Although considerable investigation was undertaken, the influence of weather on the incubation rhythm was found to be obscure. The parents brood the young by day almost continuously in the first week and for about half the time in the second week, but very little thereafter.

Feeding habits showed that the parent brings a mass of insects stuck together with saliva, this being normally passed in a single food ball to one nestling; with very small nestlings the food ball was divided. The parent swifts readily adopted a strange nestling added to or in place of their own. The parents moved some of the faeces but many others were left in the boxes, the older nestlings sometimes defaecating from the hole.

In a description of the fledging habits, Mr. and Mrs. Lack record that at Oxford most young swifts left the nests between the third week of July and the third week of August, the latest being on September 7. The young left equally in good and bad weather and departed in a steady stream, most of them leaving over a period of three to four weeks.

The young swift left the nest fully able to take care of itself and was assumed to migrate on the day that it left the nest. Nearly all the departures were in the morning, and no fledgling returned to its box. It was also reported that, in 1951 at least, most of the parent swifts stayed for several days after the departure of their young.

MAGNETIC MEASUREMENTS IN DEEP-SEA INVESTIGATIONS

Construction of Non-magnetic Containers

FOR its biological investigations the ship *Galathea* of the Danish Deep-Sea Expedition round the world during 1950–52 was equipped with a longer wire and a more powerful winch than previous deep-sea expeditions. Due to this and the fact that the construction of magnetometers of high precision has been specially developed in Denmark through the work of the late D. la Cour, it was thought natural to take up on the *Galathea* expedition also the problem of measuring the variation in the oceans with depth below sea-level of the magnetic field of the earth. The problem of the origin of terrestrial magnetism being still an open question, such measurements may elucidate this problem, which has become of special interest through the recent investigations of Blackett, Bullard and Elsasser. In this and the following note is described the work with this object.

To contain the magnetometers and protect them against the pressure of the water, which at the greatest measured ocean depths was about 1,000 atm., special water-tight containers had to be constructed of a non-magnetic and sufficiently strong material. None of the existing alloys known to us fulfilled both requirements except the aluminium alloy 'Hiduminium *RR*77'. Unfortunately, this alloy cannot be cast but only forged, a procedure which could not be used due to the limited economic resources and time at our disposal. However, Messrs. Paul Bergsøe and Son produced a new alloy satisfying all our requirements. This alloy is a completely iron-free β-manganese bronze with a high content of aluminium. Its characteristics are: magnetic permeability, less than 1·01; elastic limit, 28 kgm. per mm.^{2}; 0·01 per cent limit, 29 kgm. per mm.^{2}; 0·2 per cent limit, 38 kgm. per mm.^{2}; tensile strength, 70–80 kgm. per mm.^{2} at an elongation of 10–20 per cent; Young's modulus, $E = 6{,}100$ kgm. per mm.^{2}; density, 8·1. (A detailed account of this alloy is to be published shortly in Great Britain.) Messrs. Burmeister and Wain constructed two containers of this material, which for mechanical reasons were made in the form of spheres. The first container, shown in Fig. 1, is a single sphere, internal diameter 50 cm., wall thickness 10 cm., weight 1,100 kgm. The second container, shown in Fig. 2, consists of two single spheres like the former, connected by a tube 100 cm. long. Its total height is 270 cm. and total weight 1,700 kgm.

From experience with diesel engines, the containers were made water-tight without any packings, simply by direct contact between the polished surfaces of the single half-spheres, which were made as plane as technically possible.

The double sphere has been lowered four times to a maximum water depth of 6,900 m. It was found to be completely water-tight on all four occasions. The single sphere has been lowered twenty-nine times to various depths down to a maximum of 10,000 m. in the Philippine Trench. At the beginning some water leaked into the single sphere. This was found to be due partly to casting stresses, which gradually disappeared, and partly to the surfaces of its two halves being not perfectly plane, thus needing extra grinding and checking by means of a normal plane. In this way we reduced the leakage to the insignificant amount of 40 cm.^{3} at a depth of 5,000 m. Lack of time did not allow us to make further experiments to remove this residual water.

Finally, the elastic properties of the containers were tested. For this purpose the horizontal internal diameter of 500 mm. was measured before and after the descent of the single sphere to 10,000 m. in the Philippine Trench. A reduction of diameter of at most 0·04 mm. was found. The corresponding figure for the double sphere at a depth of 6,900 m. was 0·01 mm. Also the elastic reduction of the spheres while lowered was measured. At a depth of 6,900 m. we found that for the double sphere the vertical internal diameter of 500 mm. had been reduced by

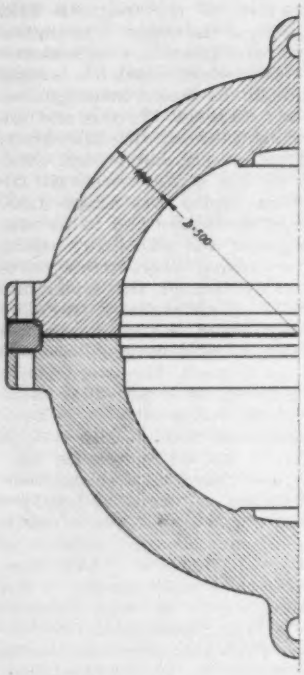

Fig. 1

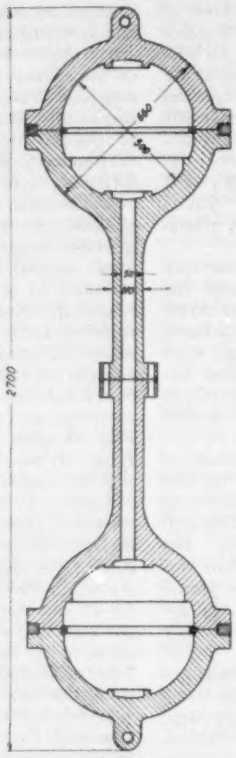

Fig. 2

at most 1·2 mm., that is, by an amount not exceeding 0·24 per cent.

Thus our results show that it is possible to construct containers allowing ordinary magnetic and other physical instruments to be lowered to even the greatest ocean depths. Apart from magnetic work, these spheres may also be used for gravimetric, seismic, cosmic ray and other work. We shall be very pleased to put our spheres at the disposal of others for such investigations.

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Magnetic Investigations on the *Galathea* Expedition

Three self-recording, relative magnetometers have been constructed: (*a*) and (*b*) measuring the horizontal component *H*, and (*c*) measuring the vertical component *Z*. The principle of (*a*) and (*c*) is that the deflexion of a magnetic needle of the la Cour monad type from a vertical and a horizontal position, respectively, is measured optically on a moving photographic film. The principle of (*b*) is that the earth's field induces an alternating current in a coil rotating about a vertical axis. This current is recorded on a magnetic recorder after having been amplified by an electronic amplifier, the amplification of which is inversely proportional to the frequency with which the coil rotates. Instruments (*a*) and (*c*) are housed successively in the single sphere, (*b*) in a double sphere, described in the preceding communication. The lower sphere of the double sphere contains the coil driven by an axle through the tube, with a motor in the upper sphere, which contains also the batteries for the motor, the amplifier and its batteries, and the recorder. To obtain sufficiently high measuring accuracy in all three instruments, most of the field to be measured is compensated by suitable magnets, so that only a small fraction is actually measured. Furthermore, in (*a*) and (*b*) these compensating magnets have the form of compass needles to give the direction of the magnetic meridian.

Within a total time of about 270 hr. which could be spent on magnetic work at sea during the expedition, our instruments were lowered twenty times to various depths of water down to 5,000 m. The first part of our programme was to make trial experiments with the instruments and adjust them to the working conditions at sea, to work out the method of observation such as manœuvring the ship, checking the tables of Vestine *et al.*[1] which form the basis for the adjustment of the instruments, investigating the perturbing effect of the ocean bottom, and so on. The second part of the programme was to use the results of the first part to take measurements at a depth of water of 5,000–6,000 m. in the central part of the Pacific Ocean, which offers great areas with flat bottom. However, due to lack of funds to meet the rising prices, the working time of the expedition had to be cut down. Thus lack of time prevented us from carrying out the second part of our programme.

The main problem in reaching the desired measuring accuracy, namely, about 10 γ, was found to be the fact that due to the weight of the spheres the wire unwound itself, thus rotating the spheres about the vertical with speeds too fast for the instruments. (To investigate both the rotation and oscillations of the spheres a special instrument was constructed recording the motion of the spheres.) This problem was solved by means of a special ball-bearing swivel inserted between the sphere and the wire, a 3-m. long aluminium rudder on the sphere, and finally by manœuvring the ship in such a way that at each depth at which magnetic measurements were taken the sphere moved horizontally at about 1 knot, which speed was found to be sufficient for the rudder to keep the spheres in a definite azimuth.

The following results were obtained. A method has been worked out whereby in any event an average value for *H* with an accuracy of about 5 γ can be measured within an hour down to at least 3,000–4,000 m. Furthermore, at a given depth at which magnetic measurements were taken the observed variation of the field with the position of the sphere showed that a rugged ocean bottom gave considerable perturbations as long as the

instruments were not at least 2,000–3,000 m. above the bottom. Finally, we found that at most stations the tables of Vestine *et al.*[1] agreed surprisingly well with the field we observed. However, at a few of our stations in the Pacific we observed anomalies where the field deviated by about 500 γ in H and about 1,000 γ in Z from the values given in the tables.

Although on the stations given by the plan of the expedition it was not possible to eliminate with certainty the perturbing effect of the bottom, all our measurements indicate that both H and Z increase numerically with increasing depths below sea-level. These findings are in agreement with what has recently been found in mines by Runcorn *et al.*[2]. Lack of time prevented us from obtaining on this expedition a physically reliable measurement of the vertical gradient of the field independent of the perturbing effects of the bottom, but we hope to be able to utilize our experiences and results on future deep-sea expeditions, and we ask anybody planning such expeditions to get into touch with us to consider the possible continuation of this work.

A detailed account of the present work will be published in the *Journal of Geophysical Research*.

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A NEW METHOD FOR THE PAPER CHROMATOGRAPHY OF OLIGOSACCHARIDES

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ALTHOUGH the application of paper chromatography to the separation and identification of bioses and higher saccharides was reported in 1948 by Partridge[1], and has since been used with advantage in numerous studies, the effectiveness of the method is still limited considerably by the low R_F values of these substances. In theory, the absolute distances separating components can be suitably increased by prolonging the irrigation time to several days; but, unless excessive care is taken, such a procedure often results in irregularities of the solvent front, and in any event is frequently too lengthy to be of use. Alternatively, the rate of movement of the oligosaccharides down the paper can be increased, as described by Hough, Jones and Wadman[2], and by Jeanes, Wise and Dimler[3]. The former workers ran the chromatograms at 37°, a procedure which is not altogether suitable for general use. Jeanes *et al.* increased the water content of the solvent and also introduced the multi-development technique; for example, with a solvent containing equal parts of fusel oil, pyridine and water, two to four developments, each of 22 hr., gave discrete spots of amylosaccharides ranging from maltose to the decaose.

We now report a new method, based on a different principle, by which considerable increases in R_F values (about eight-fold for disaccharides) may be effected; it involves the conversion of the oligosaccharides, on the chromatogram, into the corresponding N-benzyl glycosylamines, thus reducing their preference for the cellulose–water phase. Conditions suitable for the resolution of dextrins containing up to about ten sugar units have been determined; but there is no reason why, when the necessity arises, this range should not be extended by further modifications of the type described by Jones[2], Jeanes[3] and their co-workers.

After studies of the various factors involved, the following method was selected as being most suitable for general purposes: a spot of the sugar solution (2 μl.) is allowed to dry on the paper (Whatman No. 1), a spot (3 μl.) of a 10 per cent solution (w/v) of benzylamine in methanol is superimposed, and the paper is heated at 85° for 5 min., before being irrigated in the usual way with the upper phase of an *n*-butanol–ethanol–water–ammonia (40 : 10 : 49 : 1) mixture. After being dried, the paper is sprayed with a 0·25 per cent solution of ninhydrin in ethanol. The spots begin to appear within an hour, are fully developed after about 12 hr., and begin to fade after three days. The excess of benzylamine forms a band at the solvent front.

It is important that the sugar and benzylamine spots should be applied in the order given above; for best results only one spot of the sugar solution should be applied, otherwise succeeding spots tend to concentrate the sugar in a ring and the benzylamine is then less effective. Moderate amounts of impurities, such as mineral matter, organic acids, etc., do not interfere with the condensation. In view of the excessive amounts of benzylamine used, the initial spots of different test mixtures should not be closer than 3 cm. Although the N-benzyl glycosylamines stain with aniline hydrogen phthalate almost as well as the corresponding free sugars, the ninhydrin spray is more sensitive, and, moreover, does not detect the free sugar (*c.* 20 per cent) which remains after the reaction with benzylamine. About 5 μgm. of maltose or panose can be detected comfortably in an 18-hr. run; there does not appear to be any tendency for a major constituent in a sugar mixture to mask a minor one, provided that their R_F values differ sufficiently to permit the formation of discrete spots. It is desirable that the initial sugar solution should be free from impurities which, after development with an ammoniacal solvent, will stain with ninhydrin (for example, amino-acids, high concentrations of carboxylic acids); but if such impurities cannot be avoided, then their behaviour on a chromatogram must be known. A distinction between amino-acids and fairly strong spots of N-benzyl glycosylamines can be obtained by heating the sprayed paper for 2–3 min. at 85° after drying; under these conditions the glycosylamine derivatives, in contrast to the amino-acids, stain brown before turning to purple. Such heating causes no marked reduction in the time taken for N-benzyl glycosylamine spots to reach their maximum intensity. As evidence that the sugars do, in fact, move as N-benzyl glycosylamines, the spot obtained in the case of glucose has been shown to correspond to that of authentic N-benzyl glucosylamine[4] run in the same solvent (R_F *c.* 0·7).

Typical mixtures which can be resolved by the general method in 18 hr. are: (*a*) maltose and *iso*maltose; (*b*) *iso*maltotriose and panose; (*c*)

maltopentaose and maltohexaose (see also Fig. 1). The method is satisfactory for galactose, mannose, rhamnose and xylose (and presumably for oligosaccharides derived therefrom), but not for fructose. The N-benzyl glycosylamines of arabinose and ribose appear to be rather unstable under the conditions of the general method, but suitable modifications doubtless could be devised to meet these cases, if required.

For mixtures of disaccharides which give benzylamine derivatives with almost identical R_F values, it is usually better to employ an irrigating solvent containing less water than in the general method; for example, a distinction between *iso*maltose and gentiobiose can be observed readily in 28 hr. using the organic phase of a butanol–ethanol–water–ammonia (45 : 5 : 49 : 1) mixture (see Fig. 2).

With mixtures containing the higher oligosaccharides, improved results are obtained if the general method is modified in two ways: (*a*) by using a solvent of higher water content, namely, a mixture of butanol, ethanol, water and ammonia (40 : 12 : 20 : 1), and (*b*) by using a more efficient method of equilibration (see below). Under these conditions, the benzylamine derivatives of the higher homologues of maltose and laminaribiose have, respectively, the following approximate R_F values: tetraose, 0·36, 0·45; hexaose, 0·19, 0·32; octaose, 0·07, 0·21. Since laminarioctaose moves 8 cm. from the starting line in a 19-hr. run, it is clear that the method is capable of dealing with even higher saccharides, particularly if the running time is extended, or the water content of the solvent is increased still further. Within the range of saccharides examined, there seems to be little or no decrease in staining power, per reducing group, with increasing chain-length.

Thorough equilibration of the tank before the commencement of the run has a markedly beneficial effect on the R_F values of the slower-moving oligo-

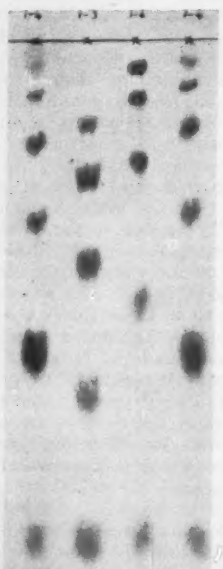

Fig. 1. Chromatogram run for 18 hr. according to the general method. Besides glucose, spots are apparent corresponding to the oligosaccharides containing up to six glucose units in the 1 : 4-α series, and up to five in the 1 : 6-α and 1 : 3-β series

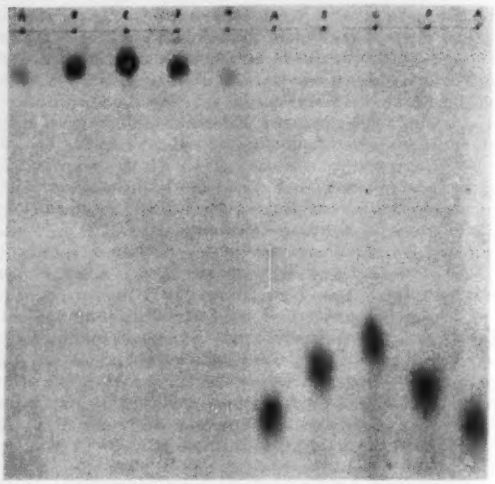

Fig. 2. *A*, maltose; *B*, *iso*maltose; *C*, gentiobiose; *D*, lactose. *Right:* Sugars treated with benzylamine and chromatogram sprayed with ninhydrin. *Left:* Identical sugar solutions run in the same solvent in the normal way and chromatogram sprayed with aniline hydrogen phthalate

saccharides. The usual method of equilibration, involving the use of trays of the solvent mixture in the bottom of the tank, takes at least 24 hr. and, during this time, glycosylamines are sometimes produced by interaction between ammonia vapour from the solvent and the N-benzyl glycosylamine spots. Since ammonia is essential in order to prevent hydrolysis of the N-benzyl glycosylamines, the following rapid method of equilibration was used. A blank sheet of filter paper was dipped into the irrigating solvent and suspended from a second trough in the tank. The solvent was introduced immediately into this trough, and the tank was sealed for 45 min., before the solvent was introduced through an orifice into the trough supporting the actual chromatogram. The degree of equilibration thus attained was better than that effected in 24 hr. in the usual way. Although this simple technique was designed primarily for use with the higher oligosaccharides, we find it beneficial also in the general method.

Following earlier theoretical considerations[5], Bate-Smith and Westall[6] deduced that $\Delta \log\left(\frac{1}{R_F} - 1\right)$ should be constant within a homologous series; they obtained good experimental confirmation with various phenolic compounds. Jeanes *et al.*[3] demonstrated later that the relationship, and also its approximation for low values of R_F, namely, $\Delta \log 1/R_F$, were true for a series of amylosaccharides. The benzylamine method enables these relationships to be tested over a wide range of R_F values. Preliminary studies with partially hydrolysed amylose and laminarin have shown good agreement, glucose excepted, with the relationship of Bate-Smith and Westall[6]; but, rather unexpectedly, with partially hydrolysed dextran. Jeanes's approximation holds better. A fuller examination of these and other homologous series of oligosaccharides, covering all types of glucosidic linkages, would enable a possible structure(s) for any oligosaccharide containing mixed glucosidic linkages to be assigned more accurately than in the past from the position of its spot relative to suitable markers. One advantage which would be gained thereby is

that, if a trisaccharide of this type were detected in the hydrolysis products of a polysaccharide, then the two different linkages of the triose would be proved to be adjacent in the polysaccharide itself.

In partial hydrolysates of the dextran synthesized by *Betacoccus arabinosaceous* (Birmingham strain) we have observed, *inter alia*, spots corresponding to a 1 : 3-biose and (more faintly) to a triose ; the position of the latter spot indicated that the triose contained a 1 : 6- and a 1 : 3-link. These observations suggested that the linkages at the branch points of this particular dextran molecule were of the 1 : 3-type, and not of the 1 : 4-type, as has been believed hitherto[7]. A full chemical analysis has confirmed that this is so[8].

Again, a partial hydrolysate of the polyglucosan of *Aspergillus niger* (strain 152), which was known already to contain 1 : 4- and 1 : 3-links in almost equal amounts[9], showed only one triose spot, the position of which indicated that it contained one of each of these linkages. Thus, it was highly probable that, in the polyglucosan, the 1 : 4- and 1 : 3-glucosidic bonds were arranged alternately ; confirmatory evidence of this has now been obtained by other methods[10].

The above observations are reported in the belief that they represent a real advance in the chromatography of oligosaccharides ; and, to the extent that paper chromatography is a useful preliminary to the isolation of crystalline reference compounds, that they will aid the determination of polysaccharide structures.

We are indebted to Prof. M. Stacey for his interest and advice, and to Dr. E. T. Dewar who kindly supplied the laminarin employed. [Sept. 29.

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PATTERN DISCRIMINATION AND THE VISUAL CORTEX

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DURING recent years attempts have been made to explain the organization of the cerebral cortex in terms of electronic computing machines. Comparisons have been made with two-way switches, regenerative storage systems and cathode ray tube scanning-systems ; yet none of these analogies has met with general acceptance, nor have they led to testable hypotheses.

We have made an attempt to examine some of the problems associated with pattern discrimination and the organization of the visual cortex by means of two approaches, each of which is fundamentally statistical. On one hand, some of the elements of the visual cortex have been described in a statistical manner (D. A. S.) while, on the other hand, the organization of a machine operating on a probability basis has been explored (A. M. U.). It is suggested that a valuable analogy exists between the two methods of study. Some relations between them are beginning to emerge, and already there has been a surprising measure of agreement between hypotheses suggested by the theory of the machine and the experimental observations of cortical structure.

There is reason to believe that many of the complexities of the cerebral cortex are due to an organization that is fundamentally of a statistical nature and the parameters of which can only be described in terms of probabilities. One of the obstacles to the formulation of adequate hypotheses for many branches of biology has been the language and mathematics which have been used in attempts to frame these hypotheses ; consequently, some of the concepts that we introduce will be strange to biologists. Nevertheless, we feel that the effort to master this approach will be amply repaid.

First of all, the finer branches of the axons running from the thalamus to the primary sensory areas of the cerebral cortex end in an apparently random manner among the surrounding cells and their dendrites. Quantitative study of the lengths of the dendritic processes and their branches shows that there is no simple law relating these lengths to the position of the cell or the size of the perikaryon.

With this background, one of us (A. M. U.), working in the field of computer design, has proposed definitions of the word 'pattern' in terms of set theory, and of 'measure of pattern difference'. These definitions have led to the design of an efficient machine with random connexions between its units and the inputs, and with the ability to measure differences between a representation and a constantly changing statistical description of past representations.

By a 'representation' is meant a set of physical quantities internal to a machine, which are determined by an external physical configuration and may be called attributes of it ; each attribute will have a measure, which may be continuous or discrete. By a 'pattern' is meant a subset of such measures. A machine for comparing a present representation with a past ensemble of representations, member by member, requires a storage capacity that must grow with the ensemble, and each comparison leads only to a binary statement of identity or difference. If, on the other hand, a statistical method of describing the ensemble of representations is used, whereby the ensemble is specified by the relative frequencies with which the different sets of attributes have occurred in the past (or the probabilities that the members of the 'given' ensemble possess certain sets of attributes), and if the comparison is made only with this system, then a constant storage capacity is all that is required. For example, if there are n input quantities (attributes) and each has s possible discrete measures, the number of different possible representations can be shown to be $(1 + s)^n$; this is the fixed number of descriptive probabilities that must be stored, regardless of the number and type of past representations.

The simplest possible machine of this nature must employ the simplest possible measure for which s is unity. In this case, either a proposition of the form

'the configuration A possesses the property j' is made, or no proposition is made at all. This measure will be called unitary, in contrast with binary measure in which an additional proposition of the form 'the configuration A does not possess the property j' is made. The input, therefore, must possess two states; if it is active, a proposition is made, and if it is inactive, no proposition is made.

An example of the kind of mechanism that could provide an input of this unitary nature would be a threshold-operated detector which could be in one of only two states. The detector would be in an active state if, say, a chemical concentration or a packet of radiant energy exceeded a certain value; otherwise the detector would be inactive. There must be no varying degree of activity in any one input channel to the machine. In consequence, for detectors of a different nature, it would be necessary to interpose a coding system between them and a machine of the type which has been described.

Using this unitary measure, a complete non-redundant statistical description of an ensemble of representations consists of the joint probabilities of occurrence of all possible sets of attributes. It is therefore necessary to have units capable of counting and storing these probabilities; and the units must be connected to the inputs in all possible ways. This can be achieved precisely by random connexions between the input points and the units of the machine; it can be shown that if the chance of any unit being connected to any particular input is $\frac{1}{2}$, each unit will be replicated about the same number of times. Other laws describing the probabilities of connexions will lead to other population distributions.

In order to define a measure of pattern difference between a present representation and a past ensemble in respect of a set of attributes, the following axiom is laid down: if the set can be separated into two subsets with *a priori* independence, the pattern difference in respect of the total set is the sum of the pattern differences in respect of the two subsets. From this it can be shown that the only possible measure of pattern difference is the negative logarithm of the *a priori* probability of the set; if the set does not occur in the present representation, there is no measure of pattern difference. Probabilities must therefore be computed in the units on a negative logarithmic scale.

For a past ensemble occurring as a sequence in time, each unit must have two properties: it must possess some quantity which grows approximately logarithmically with time, and the act of counting must consist in the destruction of some of this quantity. Different mathematical laws of growth and destruction lead precisely to different weighting functions of past events. The act of counting must occur only if all the connected inputs are in the active state caused by occurrence of the corresponding attributes.

The machine can be extended to measure a difference in respect of a pattern, even if some of its attributes have not occurred; it can be shown that the measure must be the negative logarithm of the conditional probability of the set of attributes.

Conditional probabilities can be computed in the following manner. Consider attributes j, k and l; there will be units storing $-\log p(jkl)$ and $-\log p(jk)$, the negative logarithms of the probabilities, in the past, of the sets (jkl) and (jk). If (jk) occurs, then the conditional probability of the set (jkl) is $p(jkl)/p(jk)$; so that on a negative logarithmic scale the (jkl) unit should contain $-\log p(jkl) - (-\log p(jk))$. This can be achieved if the momentary decrease in the (jk) unit, from $-\log p(jk)$ to zero, is communicated to the (jkl) unit. This effect has been called supercontrol; it leads to precise laws defining the connective function between units; these laws are different from those required between inputs and units for counting purposes. An electromechanical model of the basic unit has been built embodying the principles described and which possesses all the necessary properties of counting, storing and interconnexion.

Returning to the problem of random connexions, the simple statement that the probability of connexion is $\frac{1}{2}$ cannot lead to a knowledge of the position of units in relation to a set of inputs; this will be determined by the manner in which the probability of connexion depends on the position of the input relative to the unit. It can be said that there is a connective probability field surrounding a unit; from the form of this field it is possible to calculate the distribution of units which are directly connected to inputs for the purpose of computing unconditional probabilities. Supercontrol employing interconnexions between units leads to the concept of an indirect connective probability field. For the two forms of control to be effective, the direct and indirect fields must be of approximately the same form; it can be shown that this is met if they fall off exponentially with distance from the unit.

It is possible to define the probability of connexion between an incoming axon and cortical dendrites according to our limited knowledge of the physiology of the connective process and the morphology of the cell. It has been shown experimentally (D. A. S.) that this direct connective probability field does, in fact, fall off exponentially with distance from the perikaryon. This is equally true of the basal dendrites of the pyramidal cells.

To calculate the actual numbers of connected units a second factor is required, the packing density of the perikarya; this has also been determined. It has therefore been possible to predict the population distribution of cells connected to different numbers of afferent fibres.

Finally, we wish to stress the fundamental importance of the decisions: (*a*) to base the theory on the statistical description of an ensemble; (*b*) to adopt a continuous measure of pattern difference; and (*c*) to employ a unitary measure of attributes. The binary measure of pattern difference leads to binary machines employing the gating principle; such a pattern machine can handle two-valued logic, but it can compare only single items, not ensembles. The result of the comparison is of the form 'A differs from B' or 'A does not differ from B'. The continuous measure leads to statistical machines employing the analogue principle; such pattern machines can compare two ensembles, or a single item with an ensemble. The result of the comparison is continuous and has the form 'Item A differs from ensemble C by more than does item B'.

A full account of the mathematical concepts involved and a detailed description of the application of the theory to specific problems will appear elsewhere.

We wish to thank Prof. J. Z. Young for his encouragement and valuable criticism of this work. Acknowledgment is made by one of us (A. M. U.) to the Chief Scientist of the Ministry of Supply for permission to publish this paper.

[Nov. 20.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Investigation of the Cœlacanth

It was my privilege to carry out detailed investigations on the first Cœlacanth, and to have discovered what appears to be the area where those fishes still live.

The recent Comoran Cœlacanth, while mutilated more than was at first realized, nevertheless retains most of the soft parts, including the abdominal viscera. This extends enormously the scope of the investigational work that may be carried out on the specimen. There will be still more that can be done only on parts, exudates, and secretions from an untreated fresh specimen, which it is hoped to seek before very long.

It is in keeping with the importance and scope of the investigations on all parts of this fish that they should be assigned to leading experts in the field in which they fall. I have advised the South African Council for Scientific and Industrial Research, and have requested the Council's approval of and co-operation in this matter.

Application to be included in this scheme should be sent either to the South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, or to me personally at Rhodes University, Grahamstown. While every possible facility will be granted to selected visiting specialists, it should be noted that there is no possibility of financial aid from this end.

The ownership of the next specimen or specimens is of less importance than their proper preservation for scientific purposes. As certain organs and body fluids require special treatment and preservation, it is intended to compile a set of special instructions to be issued to those in areas where it is possible that a fresh Cœlacanth may be obtained. It will be appreciated if those interested will kindly furnish detailed special instructions composed in language as simple as possible, giving full directions and not only the names, but also the actual composition of any materials to be employed.

Since there is a hope that more Cœlacanths may be found at the Comoro Islands, it is desirable that all such materials should be available there.

J. L. B. Smith

Rhodes University,
Grahamstown.
Feb. 8.

Plastic Properties of Coking Coals

The processes which take place when a coking coal is turned into coke by heating in the absence of air are very complex and only partly understood, though they have been studied for many years[1,2]. We have made a renewed approach to the problem, and have evolved for guidance an elementary theory applicable in the temperature-range within which coking coals show plastic properties. Supporting experimental evidence is described below.

It is widely accepted[1] that a coking coal at temperatures of the order of 300° C. and higher shows plastic properties, the word 'plastic' being used here in a general sense; and there is evidence that it behaves as a liquid having a normal viscosity–temperature relationship[3]. At temperatures approaching 400° C., this liquid is subject to thermal decomposition and changes into a gas and an infusible solid. We assume this change to take place according to the laws governing first-order chemical reactions, so that if at time $T = 0$ there exists a mass m_0 of coal in the liquid state, at a later time $T = \tau$ there will remain a mass:

$$m_\tau = m_0 \exp -k\tau,$$

where k is the velocity constant of the decomposition reaction at the temperature of the decomposition; and at any later time $T = \tau + t$, there will be:

$$m_{\tau+t} = m_0 \exp -k(\tau+t) = m_\tau \exp -kt. \qquad (1)$$

The time $T = 0$ can never be experimentally realized, as some decomposition must take place in the period of heating to the required temperature, which for reasons of fundamental and experimental limitation cannot be made infinitely short. The time $T = \tau$ is taken to be the time when the predetermined temperature has been reached.

As the solid product of decomposition accumulates, the viscosity of the liquid/solid mixture will rise. We assume a relationship of the form:

$$\bar{\eta} = \eta(1 + \lambda c),$$

where λ is a constant later shown to be equal to, or not far from, unity, η is the viscosity of the mixture before the concentration of solid matter is increased by c, after which it becomes $\bar{\eta}$. (A fixed value of λ cannot be assumed, *a priori*, to apply over a long period of time, but it can be shown that it approaches constancy over periods which are not infinitesimal. Idealized extreme cases of solid suspensions and analogous systems have been studied by G. I. Taylor[4] and A. Einstein[5].) It follows that

$$\eta_{\tau+t} = \eta_\tau \left(1 + \lambda \frac{m_\tau - m_{\tau+t}}{m_{\tau+t}}\right); \qquad (2)$$

and substituting from equation (1), we have:

$$\eta_{\tau+t} = \eta_\tau (1 + \lambda \exp kt - \lambda),$$

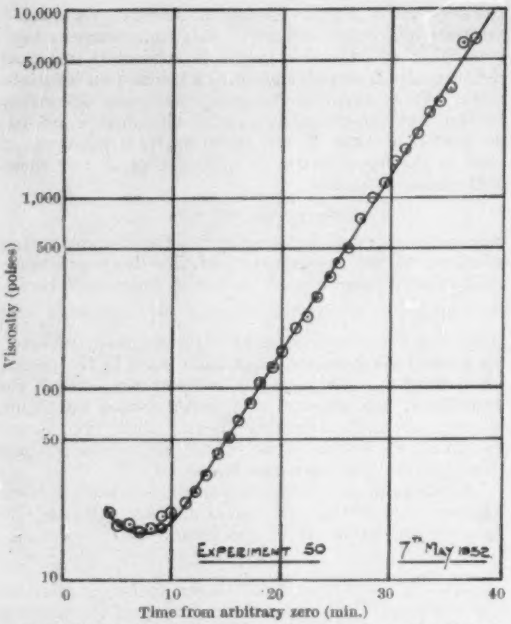
so that:

$$\frac{d}{dt}(\log \eta_{\tau+t}) = \frac{\lambda k \exp kt}{1+\lambda \exp kt - \lambda} = \frac{\lambda k}{(1-\lambda)\exp -kt + \lambda}. \qquad (3)$$

This equation makes the following statements concerning the slope of the graph of $\log \eta$ against t: (i) for $t \to 0$, the slope tends to λk; (ii) for $t \to \infty$, the slope tends to k. Thus, as t increases, the slope changes from λk to k.

The predictions of the theory were checked by measuring the viscosity of four different coals at various temperatures using an apparatus developed by Gieseler[6] and other workers[7]. A stirrer is embedded in compressed powdered coal in a crucible. A torque is applied to the stirrer which makes it rotate when the coal softens on heating. The viscosity of the coal is inversely proportional to the rate of revolution of the stirrer. In the past, the apparatus has been used for observing the viscosity changes with rising temperature, but there is no difficulty in adapting it to work at constant temperature.

The graph shows the result of a typical experiment. A linear relationship between $\log \eta$ and t is clearly shown. The precision of the experiment is such that a slight curvature would not be detected. Exact linearity would imply $\lambda = 1$ (see equation 3), so that the slopes give the reaction velocity directly. The graphs obtained permit the statement that λ is a



Results of a typical experiment on 'Manvers coal' at 414 ±½° C.; the slope is 0·094 min.$^{-1}$

constant in the range $0{\cdot}8 < \lambda < 1{\cdot}2$. The value of λ does not affect the calculation below.

Experiments have been carried out at a number of temperatures, for each coal, so that the values of λk can be used to find the activation energy of the carbonization process, using Arrhenius's equation:

$$\log k = \frac{-E}{RT} + \text{constant},$$

where E is the activation energy, R the gas constant, and T the absolute temperature. Graphs of $\log k$ against $1/T$ gave straight lines for each of the coals examined.

The table gives details of the four coals used, together with the activation energies found. It is interesting to note that although these coals differ widely in their coking properties, assessed by conventional criteria, all the activation energies are near 50 kcal./mole, which has been quoted as the energy required to break the carbon–carbon bond in the thermal decomposition of mineral oils[9].

Details of Coals Used

Coal		Volatile matter† (dry ash-free) %	Agglutinating value‡	Temperature-range over which E is determined (° C.)	Activation energy (kcal./mole)
Name	Type*				
"Maritime"	301	24·6	26 : 1	419–448	52·7±2·8
"Manvers"	502	37·6	23 : 1	406–427	48·2±2·4
"Blackwell" (blend)§	602/401	38·0	20 : 1	402–422	54·2±2·2
"Grassmoor"	702	40·0	17 : 1	405–426	47·3±1·2

* Coal Survey Classification, according to: Survey Paper No. 58, "Rapid Survey of Coal Reserves" (Fuel Research Division, D.S.I.R., H.M.S.O., 1946).
† According to B.S.1016.
‡ According to B.S.705.
§ Of which 25 per cent has 31·8 per cent dry ash-free volatile matter content and 75 per cent has 41·0 per cent dry ash-free volatile matter content.

The values we have obtained agree well with those of van Krevelen and co-workers[10], who used a very different method on a series of broadly similar coals.

This work is being continued at this Establishment, along the lines indicated, and is published by permission of the Director-General, Scientific Department, National Coal Board. A fuller treatment will be published elsewhere.

J. Bronowski
D. Fitzgerald
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Selenium Hexafluoride: Dielectric Strength and some Chemical Properties

The physical and chemical properties of selenium hexafluoride have received little investigation[1,2]. We have prepared selenium hexafluoride by reaction of the elements at 300° C. in a copper tube, and found that, provided steps are taken to return selenium tetrafluoride (boiling point, 106° C.) to the reaction zone, a yield of more than 90 per cent selenium hexafluoride is readily obtained. The gas was condensed in a trap cooled to − 160° C. and afterwards sublimed into an aspirator. The greater part of the small amount of selenium tetrafluoride collected remained in the trap after the selenium hexafluoride had sublimed. The product was scrubbed with 10 per cent sodium hydroxide solution, condensed in liquid air, and transferred to an evacuated steel cylinder cooled in 'Drikold'.

The vapour density of a sample of the purified gas, dried by sublimation *in vacuo* from a trap cooled to − 80° C., was determined by direct weighing and the molecular weight found to be 192·6 ± 1 (theoretical value, 192·96).

Hokhberg and Sandberg[3] have reported the dielectric strength of selenium hexafluoride to be nearly twice that of sulphur hexafluoride, giving the ratio 4·63 : 2·49 : 1 for the relative dielectric strengths of selenium hexafluoride, sulphur hexafluoride and air. Their measurements were carried out using two Rogovsky electrodes of 32 mm. diameter spaced at 2–8 mm. The maximum value of pressure × gap was 220 mm. mercury × cm., and the results were extrapolated to a value of 1 cm. at 1 atmosphere pressure. They make no mention of the method of preparation or of the purity of the gases tested.

The breakdown potential between two half-inch diameter brass spheres has been measured in selenium hexafluoride prepared as above, in sulphur hexafluoride containing not more than 41 p.p.m. of

RELATIVE BREAKDOWN VOLTAGES IN SELENIUM HEXAFLUORIDE, SULPHUR HEXAFLUORIDE AND AIR

Pressure × gap mm. Hg. × cm.	Relative breakdown voltage		
	SeF_6	SF_6	Air
50	1·80	1·75	1
100	2·10	2·00	1
150	2·40	2·20	1
200	2·50	2·30	1
250	2·65	2·40	1
300	2·70	2·40	1
350	2·75	2·40	1

disulphur decafluoride and 12 p.p.m. of sulphur tetrafluoride, and in dry air. The relative breakdown voltages obtained using gaps of 0·05–8·6 mm. and pressures of ½, 1, 1½ and 2 atmospheres are shown in the accompanying table. Extrapolation of the results to a gap of 1 cm. at 1 atmosphere pressure indicates that the relative dielectric strengths of selenium hexafluoride to air and of sulphur hexafluoride to air are not greater than 2·9 : 1 and 2·4 : 1 respectively.

We have found selenium hexafluoride to be slightly soluble in alcohol and acetone, insoluble in 5 per cent aqueous sodium hydroxide solution, but soluble in 10 per cent alcoholic sodium hydroxide solution. It reacts slowly with mercury, forming mercurous fluoride, and reacts readily with a solution of sodium iodide in acetone:

$$SeF_6 + 6NaI \rightarrow Se + 6NaF + 3I_2.$$

No change in volume occurs after heating selenium hexafluoride to 500° C. for 10 min. in 'Pyrex' glass. At 700° C., reaction with the glass occurs.

We wish to acknowledge our indebtedness to Mr. G. H. F. Seiflow and Mr. J. Adams, who carried out the electrical measurements.

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Thermal Degradation of Polystyrene

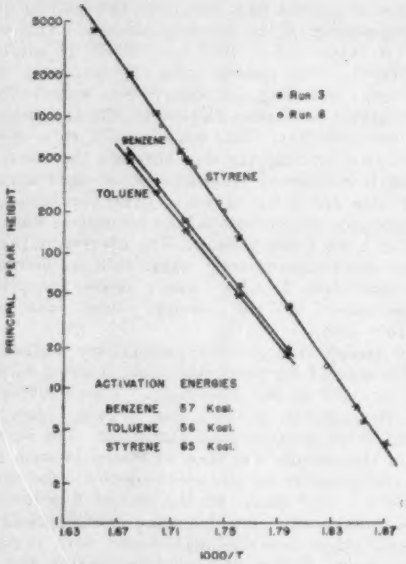
THE degradation of polymers may be elucidated by various approaches; one of the more accessible routes is a study of the volatile degradation products. Grassie and Melville[1] measured the pressure of volatilized monomer (having determined the identity of the gas by other means) from heated polymethyl methacrylate in a continuously pumped system with a constriction limiting the pumping speed to a constant value. The measured pressure was directly proportional to the rate of production of monomer. This method has been modified by using a mass spectrometer instead of a Pirani gauge. The advantages of the mass spectrometer as the pressure gauge are: (*a*) it can analyse the gas produced; (*b*) it can measure each product independently; (*c*) it has great sensitivity.

Twenty-five milligrams of thermally polymerized styrene prepared by Dr. F. R. Mayo of this laboratory was deposited as a film over 150 cm.² of quartz by evaporation of the benzene solvent. This would leave a layer $1·6 \times 10^{-4}$ cm. thick if uniformly distributed. The quartz tube (20 cm. long, 4 cm. diameter) containing the sample was sealed directly to the sample inlet tube of a General Electric analytical mass spectrometer. The sample inlet tube was the constriction limiting the flow through the ion source. It had a calculated conductance of approximately 0·012 litre sec.$^{-1}$ for styrene. The conductance of the pumping system beyond the ion source was of the order of 1,000 times greater. The maximum pressure in the spectrometer tube when rate measurements were made was 2×10^{-7} mm.; hence the pressure of monomer in the sample tube was about 2×10^{-4} mm.

The sample was given a preliminary degassing to remove solvent by pumping while heating at 80° C. for 4 hr. and at 30° overnight. The spectrometer, with the sample at 30°, had a very high background, with benzene predominating. The temperature of the sample was then increased at such a rate that the pressure in the spectrometer tube did not exceed 1×10^{-6} mm. At the end of five hours the sample was at 110°, and benzene, methyl*cyclo*hexane, toluene, ethyl benzene and acetic acid comprised 95 per cent of the material evaporating from the sample. Within nine hours a temperature of 145° was reached, and acetic acid predominated in the volatilized materials. After sixteen hours at 145°, the rate of production of volatile materials dropped, permitting the sample to be heated to 210° before large amounts of acetic acid limited the rate of heating. A temperature of 220° was reached in three additional hours. Small amounts of styrene were then observed, along with other materials, the acetic acid having decreased. The temperature was increased by small steps which brought out more acetic acid at the beginning of the next three or four increments; benzene and toluene were also produced. A temperature of 310° was finally reached. At this temperature the polymer was decomposing, chiefly to styrene, benzene and toluene, but the rates of evolution decreased with time at any one temperature. The sample was then left at 230° for about seventy hours; at the end of this period there was no measurable evolution of gas. All the results noted up to this point were ascribed to adsorbed or dissolved impurities, or odd configurations present in small amounts. The total amount of material volatilized is estimated as less than 1 per cent of the sample. The persistence of the solvent, benzene, under conditions where 'molecular distillation' would remove it in an extremely short time, indicates another rate-limiting process. This indicated a phenomenon to be considered in other investigations of this kind. The presence of acetic acid and methyl*cyclo*hexane is unexplained. The early evolution of styrene (at 220°) may have been due to desorption of unreacted monomer or scission of loosely bound monomer.

Subsequent heating of the sample from 230° to the temperature-range 260°–330° C. at intervals extending over a period of ten days showed the rates of evolution of styrene, benzene and toluene to be functions of temperature only. This is believed to be decomposition of the polymer. A plot of principal peak heights for these three materials against the reciprocal of the temperature is reproduced herewith.

From the graph, the activation energies for the production of the various substances have been derived. It is seen that benzene and toluene have



the same activation energies (57 and 56 kcal.), within experimental error, and may be produced by similar mechanisms. The styrene has a distinctly greater activation energy (65 kcal.) and must be accounted for in another way.

The rate of production of styrene may be calculated if the signal height for a given rate of flow can be established[2]. This was determined, and it was found that a rate of $1 \cdot 0 \times 10^{-4}$ µlit./sec. gave a peak height of 960 units. Hence at 330°, $7 \cdot 0 \times 10^{-3}$ per cent of the sample will decompose per minute to styrene. Extrapolations of Madorsky's results[3] for higher temperatures would indicate a maximum rate of $4 \cdot 0 \times 10^{-2}$ per cent per min. at 330°. It should be pointed out that the results described here were obtained with less than 1 per cent of the total sample degraded, and the results were obtained in the temperature-range 260°–330°. Madorsky, working in the range 335°–365°, degraded a large fraction of the sample; hence, our results are not expected to be comparable. His value of 58 kcal. for the initial activation energy was deduced from measurements of loss of weight of the sample, as was the value of 44·7 found by Jellinek[4]. In the cases cited, the weights of volatilized materials were summed, instead of measuring the rate of volatilization of each substance.

In addition to styrene, benzene and toluene, small amounts of other substances were observed, the dimer of styrene being next in abundance. Higher temperatures would be required to get reliable values for the activation energies of these other materials. The very high molecular weight materials reported by Madorsky were not observed under these conditions of degradation and measurement.

The simpler case of polymethylmethacrylate was studied in the temperature-range 170°–210°, and an activation energy of $29 \cdot 5 \pm 1 \cdot 0$ kcal. was found for the production of the monomer, essentially in agreement with 31·0 kcal. found by Grassie and Melville[1]. The problem of removing solvent and other impurities were more acute in the case of methylmethacrylate; however, when they were removed, the monomer alone was produced.

The investigation is being extended to other systems, and detailed results and interpretations will be described elsewhere.

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Interaction of Manganous Ions with Enolase

Many enzymes require the presence of metal ions for activity[1]. Kinetic studies on such systems indicate the existence of an equilibrium between the enzyme protein, the activating metal ion and a complex between metal ion and enzyme. By assuming the complex to be the only species catalytically active, a hypothetical dissociation constant can be determined from activity measurements. Considerations of this kind have led Smith[2] to formulate a theory of peptidase action according to which the metal ion acts as a binding group bringing enzyme and substrate together. Already in 1942, the same type of mechanism was suggested by Warburg and Christian[3] for the activation of enolase by magnesium, manganous and zinc ions. Since, however, no direct measurements of the interaction of activating metal ions with well-characterized enzyme preparations have been published, the present study was undertaken.

Enolase was purified by the method of Warburg and Christian[3]. These authors only investigated the activation by magnesium ions in detail, but the present work was extended to include the other activating ions. Fig. 1 shows the activity[3] of the enzyme as a function of the concentration of manganous ions measured in a 0·04-*M* phosphate buffer, *p*H 6·8. Employing the conventions of Warburg and Christian[3], the hypothetical dissociation constant of the enolase–manganous ion complex was calculated to be $2 \cdot 5 \times 10^{-5}$ mole/l. under the conditions used.

The interaction of manganous ions with enolase was also studied by the equilibrium dialysis technique[4]. Fig. 2 gives the average number of manganous ions bound per molecule of enzyme in 0·025 *M* phosphate buffer, at *p*H 6·8 and + 4°, as a function of the concentration of free manganous ions. The experimental points are too few to permit a detailed mathematical analysis, but they indicate that, in the range of concentration studied, the manganous ions

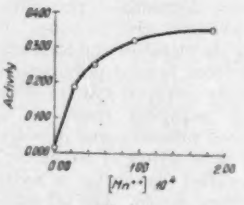

Fig. 1

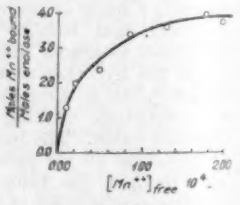

Fig. 2

Fig. 1. Influence of the concentration of manganous ions on the activity (arbitrary units) of enolase in 0·04 *M* phosphate buffer, *p*H 6·8

Fig. 2. Effect of the concentration of free manganous ions on the number bound by enolase in 0·025 *M* phosphate buffer, *p*H 6·8, at + 4°

interact with four groups of the enolase molecule, the overall dissociation constant being about 2×10^{-5} mole/l., a value of the same order of magnitude as that calculated from the activity measurements.

If it is assumed that the four binding groups are identical and do not interact, the logarithm of the first association constant can be calculated and is 5·3. Thus, the interaction of manganous ions with enolase is stronger than that demonstrated with any amino-acid or simple peptide[5-7]. It is of interest to note that the enolase molecule contains eight sulphur atoms[3], since Cohn *et al.*[8] have recently suggested that cystine may furnish the complex-forming group in metal-activated enzymes.

The work described in the present communication is being extended and a detailed report will be published elsewhere.

I wish to thank Prof. Arne Tiselius for his interest in this investigation.

Note added in proof. Experiments on the activation of enolase by zinc ions, carried out since the above communication was submitted for publication, demonstrated a fall in activity at high metal ion concentrations. This led to a re-investigation of the activation by manganous ions, which showed that the data are more correctly interpreted by assuming two types of interaction between manganous ions and enolase, one giving an active complex and the other resulting in inhibition. If this inhibitory effect is taken into account, the hypothetical dissociation constant of the active complex is found to be $4{\cdot}4 \times 10^{-5}$ mole/l. (as compared with $2{\cdot}5 \times 10^{-5}$ mole/l. above), while that of the inactive complex is 2×10^{-3} mole/l.

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A Biophysical Test for Aldohexoses

I have observed that some sugars inhibit the flocculation of bottom-fermentation brewer's yeast in tap water, whereas others do not.

Sugars which inhibit flocculation	Sugars not inhibiting flocculation
Glucose	Fructose
Mannose	Galactose
Maltose	Lactose
Sucrose (after interaction for some time)	Xylose
	Arabinose
	Dextran, etc.

The flocculation is thus inhibited by aldohexoses. This fact can be used for a quick test for glucose in the presence of fructose. About 30 mgm. of freeze-dried brewer's yeast were suspended in 5 ml. of tap water. When held at rest, the yeast flocculates, and is precipitated within one minute. On addition of an equal volume of the solution under examination, the presence of the above aldohexoses is indicated by the fact that the yeast suspension remains stable for a longer time (some hours). The influence is distinct up to a sugar concentration of 0·1 per cent.

The *p*H of the solution should be kept in the range 4–7, and the temperature above 25° C. As a condition for flocculation is the presence of calcium or magnesium salts in the medium, anions giving undissociated salts with these metals, such as oxalate, fluoride, phosphate and carbonate, should be avoided.

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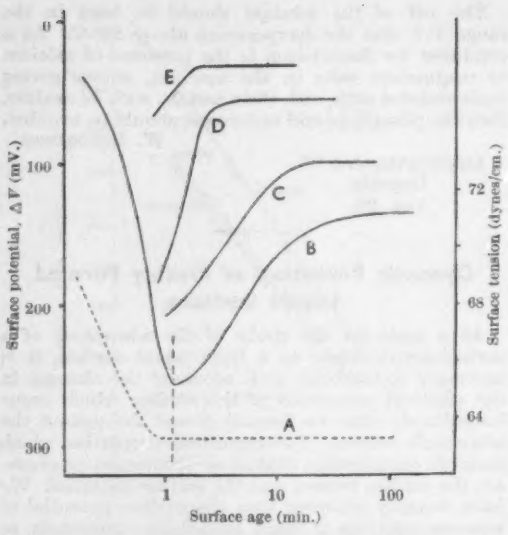
Dynamic Potentials of Freshly Formed Liquid Surfaces

As a basis for the study of the adsorption of a surface-active solute to a fresh liquid surface, it is necessary to establish with accuracy the changes in the physical properties of the surface which occur immediately after its formation, and throughout the adsorption process. Two important properties, which undergo considerable change as adsorption proceeds, are the surface tension and the surface potential. We have recently observed that the surface potential of aqueous solutions of many long-chain compounds, at the instant when adsorption is complete, differs widely from the ultimate equilibrium value. The changes in potential following establishment of concentration equilibrium between surface and bulk solution are comparable in magnitude with those occurring during adsorption, and erroneous deductions may result from the assumption that dynamic surface tensions and potentials change in a similar manner with age of surface.

Measurements of the rate of change of surface tension in aqueous solutions of straight and branched-chain alcohols[1] have shown that the surface tension of such solutions is determined primarily by surface concentration of solute, and is little influenced by molecular orientation in the surface. Changes in dynamic surface tension therefore provide a satisfactory means of following the development of an adsorbed film; when concentration equilibrium is established, no further appreciable change in tension occurs.

Curves *A* and *B* in the graph compare the change in surface tension and potential respectively for a 0·00045 per cent aqueous solution of decyl alcohol at 15°. Whereas tension is constant after one minute, the potential shows a considerable rise after adsorption is complete. In interpreting these effects, we consider that adsorbing molecules of solute arrive at the surface in a disorientated state, and that the continual arrival of solute molecules maintains this disorientation throughout the adsorption process. Unlike tension, the surface potential is influenced greatly by surface orientation as well as by surface concentration; the potential of the surface when adsorption is complete is therefore characteristic of the disorientated film. The general use of the well-known expression $\Delta V = 4\pi n\mu$ in surface potential studies implies that the decrease in the air–water contact potential (ΔV) is brought about by the solute only. However, it seems probable that the potential changes which follow adsorption are greater than can be attributed entirely to variations in the effective dipole moment μ; it is therefore considered that water as well as solute molecules are disorientated by adsorption to fresh surfaces.

When the disturbing effect of adsorption is no longer operative, the film can become rearranged to



a stable configuration. An important observation in these experiments is that the time required for the orientation process is in all cases of a different order from that required for the initial adsorption. Curves *C*, *D* and *E* (and the accompanying table) show that the effect persists down to the shortest chain-lengths, and illustrate the increase in time of orientation with length of carbon chain.

Curve	Alcohol	Concentration (%)	Adsorption time	Orientation time
B	*n*-Decyl	0·00045	70 sec.	30 min.
C	*n*-Hexyl	0·020	0·065 sec.	15 ,,
D	*n*-Butyl	0·154	< 0·005 ,,	3 ,,
E	Ethyl	0·385	< 0·005 ,,	1–2 ,,

The term 'surface potential' has therefore no meaning without reference to the age and condition of the surface. For any given surface excess, there are clearly two limiting values, the 'disorientation' and 'orientation' potentials characteristic of the two limiting surface conditions; the measured potential may lie on or between these limits, depending on the particular solute used and its concentration.

The following example illustrates the significance of these observations. A new technique for the measurement of dynamic surface tensions has been described by Posner and Alexander[2], in which the authors measured the changes in potential along jets of *iso*-amyl and *sec*-octyl alcohol solutions and translated these potential values into dynamic tensions using calibration curves derived from equilibrium values of these two quantities measured under static conditions in a trough. The dynamic tensions so deduced showed considerable divergence from the values determined by Addison[3] from jet dimensions. Since the latter values have been employed in certain theoretical studies of the adsorption process[4], it is important to investigate this divergence. The results in the accompanying graph indicate that solute becoming adsorbed to the surface of a jet must be in a state of disorientation; it has been found that, when the potential values of Posner and Alexander are translated into dynamic tensions using the appropriate tension – disorientation potential calibration curves, the results obtained by the two techniques are in almost ideal agreement.

A full account of this work is being submitted for publication in the *Journal of the Chemical Society*.

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Identification of Radiosensitive Volume with Nucleic Acid Volume

On the basis of inactivation data for nearly two dozen plant, animal and bacterial viruses, Lea[1] pointed out that the radiosensitive or target diameter was within a factor of 2 of the physical diameter of nearly all the viruses studied, the agreement becoming poorer with increase in diameter. From this agreement Lea concluded that the small viruses must be composed almost exclusively of radiosensitive material which he identified with nucleoprotein. The very large viruses were stated to be more like ordinary cells in that they seemed to have an appreciable amount of relatively insensitive 'cytoplasmic' material. Other workers (for example, refs. 2 and 3) have given experimental reasons for believing that the nucleoprotein material is the radiosensitive portion of a cell.

The first purpose of this communication is to point out that Lea's interpretation of his results may be incorrect. The source of the error is the fact that a difference of a factor of 2 in diameter means a difference of a factor of 8 in volume. On this reasoning it is improbable, except for the very smallest viruses, that the entire virus can be considered to be radiosensitive. The question then arises as to what might be identified with the target, if, indeed, any single structure can be so identified.

My second purpose is to show that a more straightforward use of the radiation data gives quantitative support to the idea that the radiosensitive portion of a virus is its nucleic acid (not its nucleoprotein).

Both radiation data and nucleic acid data have been found for ten viruses. Radiation data for the four plant viruses and two of the three animal viruses in this group have been given in ref. 1 along with the size of virus. Radiation data for the three bacterial viruses are given in ref. 2. The inactivation data for influenza are given in ref. 4. Nucleic acid data for the bacterial viruses are given in refs. 5, 6 and 7; for the remaining viruses in ref. 8. Virus densities are given in ref. 10, except for tobacco necrosis, tobacco ringspot, and vaccinia viruses; the latter were assumed to have densities of 1·3 gm./ml. The nucleic acid density was taken[8] as 1·63 gm./ml. The results of the calculations of radiosensitive volumes and nucleic acid volumes are given in the accompanying table.

It is evident that there is a good agreement between target volume and nucleic acid volume except for the largest two viruses (influenza and vaccinia); these are well known to have complex internal structures which could easily make inapplic-

Virus	Target volume (10^3 mμ^3)	Nucleic acid volume (10^3 mμ^3)
Tobacco mosaic	2·4	2·5
Tobacco necrosis	1·3	1·2
Tobacco ringspot	1·9	1·2
Tomato bushy stunt	2·0	1·8
Coliphage T2	56	86
Coliphage T6	56	86
Coliphage T7	27	26
Influenza	55	21
Shope papilloma	2·1	4·2
Vaccinia	13	194

able the single-target, single-hit theory used in the calculations. It should be emphasized that the uncertainties in the data are sufficiently large for the agreement between target volume and nucleic acid volume to be well within probable error. Similarly, of course, it cannot be excluded that the volumes could be different by, perhaps, a factor of 2.

It was not possible to use the data on nucleic acid contents of four other bacterial viruses given in ref. 9, because some of the resultant nucleic acid volumes are greater than the entire volumes of the viruses.

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Luminosity generated by Shock Waves

Luminous phenomena accompanying shock waves have been observed under extreme conditions by Michel-Lévy, Muraour and Vassy[1] through head-on collision of shocks generated by explosives, and by Perry and Kantrowitz[2] at the point of convergence of a cylindrical shock wave. A related phenomenon is observed in the gas discharges of Fowler, Goldstein and Clotfelter[3], although the creation of the shocks in this type of work is of an electrical nature and does not immediately allow a hydrodynamic interpretation.

It was noticed some time ago that the University of Michigan shock tube exhibits luminosity in gases such as air, nitrogen and argon. This shock tube[4] has a rectangular cross-section of 2 in. × 7 in., a compression chamber 7 ft. long and an expansion chamber of 18 ft. Shocks are produced in the expansion chamber by rupturing a diaphragm between it and the compression chamber, which generally contains hydrogen at a pressure of several atmospheres. Preliminary results of our investigation were reported at the Salt Lake City meeting of the American Physical Society in June 1952. At that time experiments were also reported by Kantrowitz which, although different substances were used, seem to show very similar results. In what follows, further experimental investigations are reported.

Luminosity is observed when the shock is reflected normally from a plate at the end of the tube. In order to localize this phenomenon within the space-time events taking place in the shock tube, wave-speed camera exposures were taken of the region near the reflecting plate. This established with complete certainty the fact that the luminosity is confined at first to the region between the reflecting plate and the reflected shock, until the latter meets the interface or cold front which divides the gases initially in front of and behind the burst diaphragm. From then on, the luminous region is limited by the end plate and by the expansion wave generated at the meeting of the reflected shock and the interface. The wave-speed camera pictures show a roughly triangular region, the entire duration of time of the phenomenon being between 1,500 and 3,000 microsec., depending upon the strength of shock and the nature of the gas.

Spectroscopic investigation has been carried out with a two-prism glass spectrograph, which has a dispersion of 12 A./mm. at 4000 A. and of 140 A./mm. at 9000 A. Preliminary exposures with nitrogen and argon showed merely the D lines of sodium and the g line ($^1S - {}^1P$) of calcium. According to hydrodynamical reasoning, stronger shocks with correspondingly higher temperatures can be obtained, for given pressures in front of and behind the diaphragm, when using heavy monatonic gases. Therefore krypton and xenon (we are indebted to the Linde Air Products Co., Tonawanda, N.Y., for a generous gift of rare gases) have recently been used. The following table shows the theoretical temperatures attained with three atmospheres of hydrogen in the compression chamber and the indicated pressures of xenon in the expansion chamber after reflexion of the shock from the end plate.

Xenon pressure	Temperature
32·4 mm. mercury	6,000° K.
17·8 „ „	9,000
5·7 „ „	18,000

The actual temperatures are, because of viscosity and radiation losses, somewhat lower. The last pressure and temperature just about represent the working limit of the present shock tube.

It is now possible to make a comparison of the intensity of the g line of the neutral Ca with that of the H and K lines of Ca II as the temperature increases. While for weaker shocks the g line alone is present, for stronger shocks the H and K lines increase in strength, with the g line even diminishing its intensity. This behaviour conforms to the theory of stellar atmospheres put forward by Saha, Fowler and Milne[5]. It is thus established that the luminosity of the gases behind shocks is purely a temperature phenomenon. Especially at lower shock-strengths, metallic lines are of greater prominence than the lines of the carrier gases, similar to the conditions in stellar atmospheres. Thus several hundred lines of sodium, calcium, barium, iron, aluminium, as well as bands of calcium, are observed which are due to room dust and to the walls of the tube. Further, by introducing the acetyl acetonate of copper the spectral lines of this metal were observed.

As to the lines of the carrier gas, it is obvious that xenon offers the most favourable conditions not only because of the higher temperatures attainable but also because of its comparatively low excitation potential. Indeed, at calculated temperatures above 12,000° K., xenon lines are first observed. With a single flash produced by a shock of calculated temperature 18,000° K., about fifty xenon lines below 9000 A. have been identified. These are all the lines obtainable with a xenon-filled Geissler tube after an exposure of about 2–5 min. Comparison of the xenon lines produced in these two ways appears to indicate a broadening and, in some cases, a shift—effects which were announced by Kantrowitz. In view of the results of Michel-Lévy, Muraour and Vassy and also of Schulz[6], there seems little doubt that, as the strength of the shocks increases, continuous spectra will play a more and more important part.

It is intended to apply quantitatively the theories of Saha, Fowler and Milne with the purpose of determining the degree of ionization and the electron pressure at various shock strengths. The investigation of the shapes of spectral lines under these novel conditions of rapid pressure and temperature changes should complement the information gained from astrophysical and electrical discharge studies. Like the *Schlieren* and shadowgraph methods, observation of luminous phenomena will give information on the flow of a supersonic gas stream around a model. As the incoming flow is deflected or reflected by a model, the luminosity distribution will furnish a measure of the local temperature.

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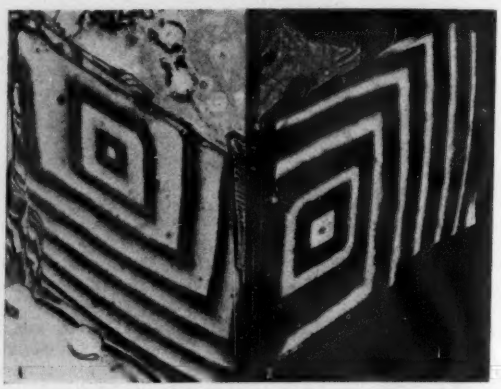
Transmission-like Reflexion Fringes in Birefringent Crystals

It has long been known that the suppression of the first beam in multiple-beam reflexion interference fringes produces a transmission-like pattern. This was established in 1907 by Lummer[1], and was recently applied by Bruce[2], who cut out the first beam by a knife edge. In high-magnification studies, this obscuration of the lens may lead to diffraction anomalies (Tolansky[3]).

In the special case of thin birefringent crystals, transmission-like systems can be obtained in reflexion by a simple optical device. If a birefringent tabular crystal is grown on a silvered optical flat and the upper surface is then silvered, we have a birefringent medium between silvered surfaces capable of producing familiar multiple-beam localized Fizeau fringes, and in reflexion such a system gives dark fringes



Magnification × 200

on a bright background. Fig. 1 gives an example using the crystal stearic acid. Owing to birefringence the fringes are double, the components being mutually perpendicularly plane polarized. However, if illuminated with plane-polarized light and the reflected system is viewed through an analyser, it is clear that, without any change of the numerical aperture, the first reflected beam can easily be cut out, since this is the only beam in the interference system which does not go through the crystal, and hence its plane of polarization differs from that of the complete multiple-beam system. Fig. 2 shows the appearance of the pattern obtained by thus suppressing the first beam. Here the two components are polarized in the same plane. It is clear that this simple technique permits not only the total suppression of the first beam but also its partial suppression if wished. Hence it is possible to study systematically the continuous change in the appearance of the fringe pattern as the contribution of the first beam is successively varied.

Detailed analysis of the system will be published elsewhere.

I wish to thank Prof. S. Tolansky for his interest and Miss P. M. Reynolds for valuable discussion. This work is being done during the tenure of an I.C.I. Fellowship while on study leave from the University of Delhi.

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Relationship between Relative Viscosity and Volume Concentration of Stable Suspensions of Spherical Particles

Many relationships have been suggested for the relative viscosity, η_r, of a suspension of rigid, smooth spheres in a liquid in terms of the volumetric concentration c. Einstein[1] obtained the equation:

$$\eta_r = 1 + 2{\cdot}5\,c,$$

for a suspension of spherical particles at infinite dilution and devoid of such influences as agglomeration, solvation, accumulation of electric charge and so forth. Other equations and empirical relationships have also been derived by different workers.

In recent work we have found it convenient to plot the value $1 - \frac{1}{\eta_r}$ against the volumetric concentration c for stable suspensions of spheres, and have obtained a straight line. The results of other workers were treated in this way, the data used including those obtained from rising sphere, rotating cylinder and capillary tube viscometers. In most cases a straight line has been obtained up to concentrations of at least 20 per cent (the highest concentration used in some of the investigations), although the data given for the suspensions of glass spheres used by Vand[2], and by Eirich, Bunzl and Margaretha[3], gave lines which curve towards the concentration axis and which closely resemble curves we have obtained for unstable suspensions.

The equation to the straight line may be written

$$1 - \frac{1}{\eta_r} = kc,$$

that is, $\eta_r = \frac{1}{1 - kc}$ or $\eta_r = 1 + kc + k^2c^2 + k^3c^3 \ldots$,

where k is a constant. At extremely low concentrations the expression reduces to

$$\eta_r = 1 + kc,$$

which, if $k = 2{\cdot}5$, is identical with Einstein's equation.

The accompanying table shows the values of k obtained from curves for the data of various workers.

Worker	Type of viscometer	Size ratio of suspended spheres	k	Range of volumetric concentration over which equation applies (per cent)
Eirich, Bunzl and Margaretha (ref. 3)	Capillary	*	2·41	0–15+
Broughton and Windebank (ref. 4)	Rotating cylinder	2·0 : 1	2·57	0–15+
Whitmore (ref. 5)	Rising sphere	1·8 : 1	2·41	0–20+
		1·2 : 1	2·77	0–20+
Eveson (ref. 6)	Rotating cylinder	1·4 : 1	2·56	0–20
Nandi (ref. 7)	Capillary	1·4 : 1	2·42	0–35
Higginbotham (ref. 8)	Capillary	1·2 : 1	2·38	0–25
Williams (ref. 9)	Capillary	5·0 : 1	2·34	25–35
Present work	Capillary	1·6 : 1	2·45	0–30

* Killed yeast, size ratio not exactly known. All other results refer to perfect spheres.

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A Theoretical Approach to the Problem of determining the Relationship between the Constants of Circuits and their Intrinsic Safety

There is an urgent need for a comprehensive theoretical correlation between the constants of a complex circuit and its intrinsic safety in the presence of inflammable gases. This has not yet been attempted owing to the lack of knowledge of the fundamental mechanism of spark ignition. I believe, however, that even in the present state of knowledge it is possible to derive a circuit theory which would permit the approximate correlation between intrinsic safety and circuit constants however complex the circuit may be.

The available evidence suggests that the principal factors controlling ignition are the nature, composition, ambient temperature, pressure and turbulence of the inflammable gas; the material, configuration and manner of separation of the electrodes; the energy dissipated in the discharge and its duration; and the volume of gas influenced by the discharge. What, in fact, appears to matter is that the temperature of a sufficient volume of an inflammable gas be raised above some critical level. Thus, for a particular inflammable gas under specified conditions and for a specified electrode system, a certain minimum amount of energy must, it seems, be imparted to the gas. This energy is the difference between that supplied by the discharge and that removed to surrounding space.

The expression for energy expended in a discharge through an opening current-carrying switch is, in operational notation,

$$U = \int_0^T [Z_p (I - i)\, i \,.\, \mathbf{1}]\, dt,$$

where I is the initial current through the switch before it starts opening at time 0; i is switch current at any time t between 0 and T; T is duration of discharge; Z_p is impedance across the open switch when all sources of voltage are short-circuited.

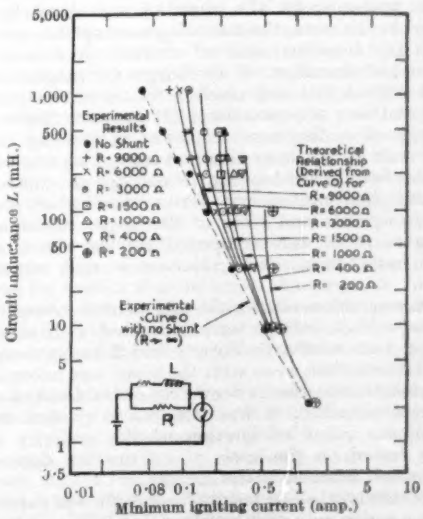

Fig. 1. Comparison between experimental results obtained by the Safety in Mines Research Establishment and the theoretical relationship derived from the curve O for the effect of shunt resistance on minimum igniting current

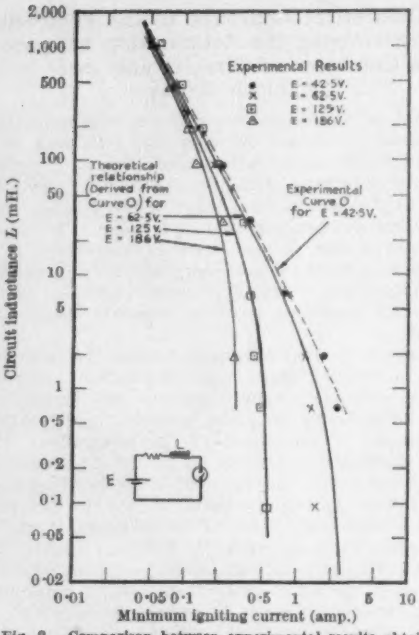

Fig. 2. Comparison between experimental results obtained by the Safety in Mines Research Establishment and the theoretical relationship derived from curve 0 for the effect of battery voltage on minimum igniting current

This energy U can be computed for any linear circuit, whatever its voltage and impedance, so long as the duration of the discharge and the manner in which current i varies are known. Non-linear circuits, such as iron-cored inductors, rectifiers and non-linear resistors, can also be treated similarly.

The above theoretical considerations were checked for non-capacitative circuits against results of tests with an 8·3 per cent methane–air mixture published by the Safety in Mines Research Establishment[1]. In the absence of information regarding current and voltage patterns or the duration of discharges obtained in the tests, the following assumptions were made: (1) constant rate of current decrement; (2) constant duration of discharge (of magnitude derived from a few test results) for each electrode system and rate of separation; (3) constant fraction of energy of a discharge employed in igniting the gas for each electrode system and rate of separation.

On this basis and adopting the concept of constant minimum igniting energy for a particular gas, electrode system and time of discharge, minimum igniting currents were computed for the effects of circuit inductance, shunt resistance and circuit voltage.

The computed results for the effects of shunt resistance and circuit voltage were compared with corresponding test results in Figs. 1 and 2 respectively. It can be seen that, even with the scant test information available at present regarding characteristics of discharges obtained, it was possible to predict the approximate point of ignition of the majority of circuits tested on the basis of information derived from a small fraction of the circuits.

Additionally, the test results for the effect of inductance in a series inductive-resistive circuit were shown to be predictable from a single test result. Finally, the effect of the rate of electrode separation reported by the Safety in Mines Research Establishment was shown to be consistent with the proposed theory.

A close agreement has thus been demonstrated between the calculated and the existing test results. New experimental work will be required to determine whether refinements of the theory are necessary to take account of additional factors, such as the recovery transient, the arc voltage or the ionization voltage; or whether, for example, a closer approximation to actual conditions is obtained if the voltage of the discharge is taken as constant or linearly rising and the discharge current is re-calculated from the above basic equation. It is proposed to publish a full report of this work elsewhere.

Thanks are due to the Director-General of the Scientific Department of the National Coal Board for permission to publish this account, and to Mr. D. R. Scott for his assistance in mathematical calculations.

B. Roston

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Conversion of Solid into Ascites Tumours

Previous studies by different authors[1–4] have shown the possibility of the conversion of solid into ascites tumours. Further observations have revealed information which promises to elucidate the nature of this conversion. In all, forty-two different mouse tumours have been tested so far.

The following procedure was used throughout. Solid tumours of various origin (Table 1) and, in most cases, homologous to one of a number of inbred mouse strains (*C3H*, *C57* black, *C57* leaden, *dba*, *Ak*, Strong *A*) were minced mechanically and 0·2–0·5 gm. of the fresh tumour pulp was injected intraperitoneally into mice belonging to the strain of origin or suitable *F*1 hybrids. The tumour was then maintained by successive intraperitoneal transfers for at least ten, but in most cases up to thirty to forty, transfer generations. While carrying out successive transfers, inoculations of peritoneal exudate in 0·4-ml. amounts were made whenever an exudate was present in appreciable amounts. If no exudate was available, solid-tumour mince was again used.

Table 1 lists the different tumour lines used with respect to their capacity for growing as typical ascites tumours. In agreement with previous definitions[3,5],

Table 1. Tumours Grouped According to Type

Tumour type	Total number	Transformation into ascites tumour		
		Successful immediately	Successful gradually	Unsuccessful
Spontaneous mammary adenocarcinoma	17	0	0	17
Transplanted mammary adenocarcinoma	6	0	4	2
Transplanted sarcoma originally induced	4	0	2	2
Transplanted sarcoma originally spontaneous	4	1	0	3
Transplanted lymphoma	5	5	0	0
Transplanted melanoma	2	0	0	2
Transplanted hepatoma	2	0	0	2
Transplanted neuroblastoma	1	0	0	1
Transplanted chondrosarcoma	1	0	0	1
Total	42	6	6	30

the term 'ascites tumour' is used for denoting the condition when intraperitoneally injected tumour cells primarily start multiplying in the peritoneal fluid, induce accumulation of ascites and eventually reach there a high concentration. The final stage represents a nearly pure culture of free tumour cells.

The tumours used fall into three different categories as regards their ability to grow as ascites tumours. Some of them give rise to typical ascites tumours immediately after their first intraperitoneal inoculation. All five lymphomas tested and one out of eight transplanted sarcomas fall into this group. Other tumours showed a more gradual transformation and resulted in typical ascites tumours after a number of exudate-transfer generations only. These two categories were already recognized when our previous experiments were reported[5]. The number of transfer generations was, however, too small to permit definite conclusions as to the third category, which included tumours that gave negative results and grew only in the form of solid neoplasms. On the basis of examination of a larger number of tumours and a more prolonged observation period, it can now be stated that, under the conditions used, a number of tumours did not lend themselves to transformation into ascites tumours. This is at variance with the opinion of Goldie *et al.*[6], that cells from any mouse tumour strain inoculated into the peritoneal cavity can induce the accumulation of fluid and multiply therein as free cells.

The question arises as to the factors concerned in determining whether the tumour cells injected can proliferate freely in the peritoneal fluid and provoke ascites production. If the tumours used are classified according to the median survival time of animal groups receiving intraperitoneal inoculations of 0·2–0·5 gm. of minced solid tumour (Table 2), it will be seen that transformation into ascites tumour occurs only with the rapidly growing tumours, although even here not invariably. Moreover, the tumours belonging to these rapidly growing categories were all highly anaplastic and had previously passed through a long series of transfer generations before being used for the present experiments. It would appear that a rapid growth-rate and/or high degree of anaplasticity of the tumour tested are necessary, but in itself not sufficient conditions for the final attainment of the ascites tumour condition.

The capacity to induce the production of ascites and to grow in this ascites are thus shown to be the attributes of certain tumour cells only. In all five lymphomas tested, and in one of the sarcomas, such an ability seems to be inherent in a large proportion of the cell population, thus making transformation into ascites tumour instantaneous. On the other hand, in the tumours that show transformation of the gradual type, this property may perhaps be associated with a small number of cells only. These cells, possibly arising by mutation, would then be selected during the successive exudate-transfer generations, where the particular cells that can survive in the fluid will always be the transmitters of the tumour. Alternatively, the transformation may be viewed as an adaptive change, in which case there would be a given chance for each cell in the original population to survive and proliferate in the fluid exudate. If the former concept is true, then an ascites tumour, when once established, should retain its capacity for growing in the ascites form immediately and at any time, even if kept routinely by subcutaneous solid transfers. The following experiment shows that this is the case for one of the tumours used.

Table 2. Tumours Grouped According to the Median Survival Times of Intraperitoneally Inoculated Animals

Median survival time in days	Total number of tumours tested	Transformation into ascites tumour	
		Successful	Unsuccessful
6–10	7	5	2
11–15	6	5	1
16–25	5	2	3
26–35	6	0	6
Over 35	18	0	18
Total	42	12	30

Table 3. Comparison between the Effect of Intraperitoneal Injections of Solid Krebs 2 Tumours of the Original Solid Strain (*SS* Strain) and the Strain Developed by Subcutaneous Injection of the Krebs 2 Ascites Tumour and Kept as Solid Tumour for Twelve Transfer Generations (*AS* Strain)

	No. of animals inoculated	No. of animals developing only solid tumours	No. of animals forming ascites	Average percentage of tumour cells in ascites
SS strain	9	8	1	None detected
AS strain	10	0	10	75

The Krebs 2 tumour (belonging to the category showing gradual transformation into ascites tumour[3,5]) has been kept in the ascites form for more than twenty intraperitoneal transfer generations. When 0·2 ml. of ascites was injected subcutaneously into *C3H* mice, solid tumours developed at the place of inoculation. Subcutaneous transfers of the solid tumours were then made by the trocar technique through twelve transfer generations. At the end of this serial transfer the tumours belonging to this line (*AS* strain, Table 3) were broken up, and 0·5 gm. solid-tumour mince was inoculated intraperitoneally to ten *C3H* mice. These inoculations provoked typical ascites tumours immediately in all animals injected, the frequency of the tumour cells in the ascitic fluids ranging from 67 to 92 per cent. This behaviour was in marked contrast to that of the original solid tumour[3] (*SS* strain, Table 3), which, on its first intraperitoneal transfer in comparable amounts, gave rise exclusively to the solid type of growth. This observation indicates a difference between the original cell population of the solid tumour and that of the solid-tumour line developed from the ascites in its relationship to growth as ascites tumours. In the line developed from ascites, this capacity was retained through twelve subcutaneous transfers, during which the cells grew in the form of solid tumours. This favours the possibility that one or several 'mutants' possessing this capacity were selected during the original procedure of transformation into ascites tumour, rather than the assumption that the transformation represents an adaptation to the fluid environment, in which case a reverse change might be expected to occur during the subcutaneous transfer generations. Experiments are now in progress for further elucidation of the question.

These investigations have been made possible by grants from the Wallenberg Foundation, Kooperativa Kvinnogillesförbundet and the Swedish Cancer Society.

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An Action Potential from the Motor Nerves of the Jellyfish *Aurellia aurita* Lamarck.

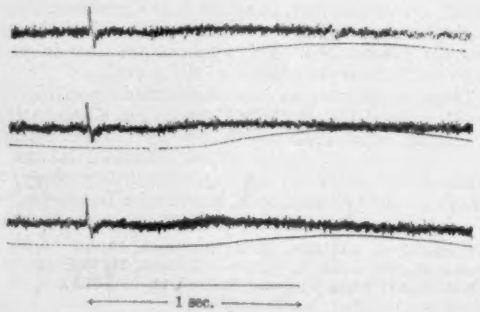
So long ago as 1878, E. A. Schäfer demonstrated in *Aurellia* a network of bipolar and tripolar nerve cells the processes of which run in all directions, frequently coming close together at points which have been interpreted as synapses[1,2]. Using Holmes's method of silver staining, I have been able to confirm this histological picture; moreover, the fibres are similar to those of the through-conducting system in the mesenteries of *Metridium*[3]. These fibres can be seen clearly in living *Aurellia* under phase-contrast or oblique illumination.

It has long been known[4] that a bridge of tissue between two pieces of *Aurellia* will conduct a stimulus in either direction, resulting in a contraction in each piece. The ability to see the fibres has made it possible to show that this transmission can occur in either direction even when only a single fibre crosses the bridge. Such conduction does not occur when no nerve fibre can be observed under phase-contrast illumination.

Physiological work has shown[3] that there is a through-conducting system in Cœlenterates which behaves in the same way as the nerves of higher animals. The existence of an all-or-nothing response and a refractory period is characteristic of nerve fibres. The above experiment with *Aurellia* shows that the observed nerves are carrying the excitation. Formerly, there was no rigorous proof of this. It is to be expected, therefore, that one or more impulses with action potentials are propagated through at least some of the fibres at each contraction wave. Direct recording from a living nerve shows that this is actually so.

The fibres of the motor nerve net can be picked up individually with a single electrode of thin platinum wire mounted on a micro-manipulator. With a condenser-coupled amplifier of long time-constant, such a preparation gives one action potential at each spontaneous beat of the bell (see traces reproduced herewith). A majority of fibres tested do not show this action potential; but one cannot distinguish between fibres that have been damaged by the manipulation and those that may be inactive.

A single electrical stimulus applied to the subumbrella surface gives rise to a contraction of the muscle, and the spread of the contraction to every part of the bell is consistent with the histological arrangement of a network of nerves. In these and other experiments I can find no evidence of polarization, interneural facilitation, or decremental conduction in this motor system of *Aurellia* except occasionally in narrow bridges where it may be due to damage. Direct recording of the impulse in a single nerve fibre shows that the excitation, which can travel in all directions, consists at each beat of a single impulse at any point. This fact gives rise to important conclusions which will be discussed in a later paper.



The interval between the nerve impulse in the upper trace and the beginning of the movement shown in the lower is not the true latent period, since they are not recorded from the same spot

There is evidence, especially in other Scyphomedusæ, that an excitation can be transmitted across the subumbrella without giving rise to movement *en route*, and presumably this must go through some diffuse system other than the motor fibres. There is not sufficient evidence to extend these conclusions concerning *Aurellia* to groups other than Semæostome Scyphozoa.

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Competitive Suppression of Prototrophs

In a recent publication[1], Jinks has compounded the erroneous impression, first given by Grigg[2], that competitive suppression is a neglected source of error in studies of prototrophs or reversions of nutritional requirement in micro-organisms. Kølmark and Westergaard[3] have shown that Grigg's criticism is inapplicable to their case; but since Jinks's publication is subsequent to this, and expresses the belief that "it is not easy to see a simple way of avoiding [the] effects" of competitive suppression, a brief recollection of the facts published elsewhere on the matter seems called for. Competitive suppression is certainly a real phenomenon and has been studied experimentally in some detail[4–6]. The findings relevant to the present issue are that: (1) the addition of prototrophs to the culture of organisms from which prototrophs it contains are being screened measures the extent of competitive suppression; (2) when competitive suppression is not acting, dilution of the culture results in a corresponding decrease in the number of prototrophs, and added prototrophs are recovered.

In Nelson's[7] studies of recombination in *E. coli*, the recovery of added prototrophs showed that competitive suppression was inoperative in a majority of crosses. In that cross in which the parents seemed to prevent the formation of colonies by the prototrophs formed, added prototrophs were not recovered. In these cases, however, suppression was exhibited only in concentrations far beyond those usually employed. Newcombe and Nyholm[8], for example, used smaller concentrations, in the range where limited testing showed ten-fold dilutions to give ten-fold decreases in numbers of prototrophs plated (Newcombe, personal communication). Similar consistent relationships between dilution and number of mutants were found in the work of Newcombe and Hawirko[9] on streptomycin resistance in *E. coli*. Moreover, in their publication they presented evidence for the recovery of added mutants in a background of parents more concentrated than that used in their determination of mutation-rates.

Similarly, studies on the reversion of biochemical mutants of *Neurospora crassa* have been performed

under conditions where competitive suppression is absent. Giles[10], whose report on this point was presumably not available to Grigg, has shown by the addition of prototrophs that the parental conidia did not prevent their expression. The results of Grigg's experiments appear to be a function of starvation conditions, as Kølmark and Westergaard have claimed. McElroy (personal communication) finds that, even when sorbose is used, competitive suppression does not operate when the agar plates are as thick as those used in his previous experiments[11].

It is no doubt correct to demand that the reliability of the screening method employed be established in each case. In spite of what has been said above, one may still ask whether mutants of recent origin differ in no way from those somewhat older or whether, as Nelson suggests, the reaction-rate constant of bacterial recombination should be used instead of the empirical frequencies of prototrophs. But it is wrong to imply that laboratory workers in this field do not appreciate and have not studied the role of competitive suppression.

FRANCIS J. RYAN

Department of Zoology,
Columbia University,
New York 27, N.Y.
Dec. 3.

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The Mitochondrial Membrane

THE mitochondrial membrane has been a subject of controversy. Two distinct problems have arisen: whether a morphological membrane exists, and, if so, whether it is semi-permeable.

As Hogeboom and Schneider[1] point out, a number of workers, starting with Claude and Fullam[2], have interpreted structures seen in electron micrographs as mitochondrial membranes. Mühlethaler, Müller and Zollinger[3] observed such a membrane and estimated its thickness to be 200 A. Harman[4], however, doubted the existence of a membrane and considered that "it is acceptable on all available evidence to regard mitochondria as tightly coiled or compact gels".

The illustrations reproduced here show mitochondria from red beet tissue prepared in two different solutions, 30 per cent sucrose and 0·45 per cent potassium chloride, by the usual methods of centrifuging. Drops of the mitochondrial suspension were placed on electron microscope specimen screens and fixed; after drying, the soluble materials were removed by diffusion into water through the collodion membrane. The preparations were shadowed with uranium. The particles prepared in 30 per cent sucrose appeared as compact spheres 0·7–1·0 μ in diameter (Fig. 1). The particles prepared in 0·45 per cent potassium chloride appeared as large diffuse disks, 1–2 μ in diameter (Fig. 2). The same extracts under a phase-contrast microscope showed, in sucrose, compact spheres, and in potassium chloride, larger

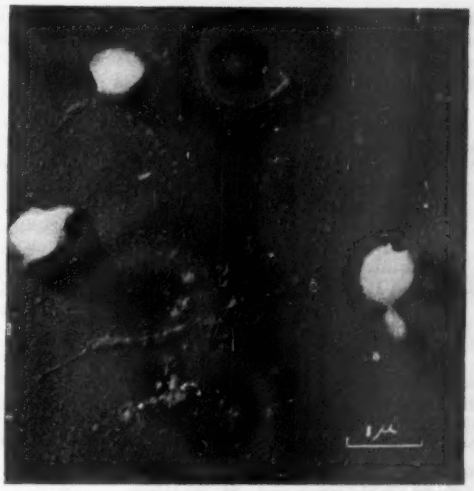

Fig. 1. Electron micrograph of beet mitochondria prepared in 30 per cent sucrose solution, fixed with formalin and shadowed with uranium; ratio of shadow length to particle height, 4 to 1

spheres with uneven patches, closely resembling the animal mitochondria prepared in potassium chloride by Zollinger[5]. The appearance of our preparations suggested uptake of water by the particles prepared in the solution of low osmotic pressure. Fig. 2 would be consistent with collapse of these particles from a sphere to a disk on drying. The disks show distinct folds or crinkles; from the length of the shadows the thickness of the membrane is of the order of 270 A. The appearance of the particles in water as swollen spheres which disintegrate after a time is evidence against the possibility that the membrane could have been formed while the particles were drying, and we conclude that these mitochondria have morphological membranes.

Fig. 2 shows a distinct membrane on a plant mitochondrion, thereby establishing beyond all doubt the suggestion made originally by Bucholz[6] and the inter-

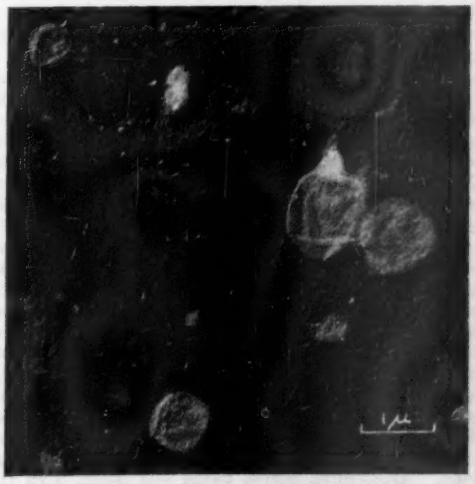

Fig. 2. Electron micrograph of beet mitochondria prepared in 0·45 per cent potassium chloride solution, fixed with osmium tetroxide and shadowed with uranium; ratio of shadow length to particle height, 4 to 1

pretation of the pictures published by Stafford[7] and Anderson[8]. Whether the membrane has semi-permeable properties and is responsible for the osmotic properties of the particle must still be investigated.

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R. N. Robertson
M. J. Wilkins

Commonwealth Scientific and
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Plant Physiology Unit,
Botany School,
University of Sydney.
Oct. 15.

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Fixation of Bacterial Products by Erythrocytes *in vivo* and by Leucocytes

It is known that, under suitable conditions *in vitro*, certain substances of bacterial origin may become fixed on to the surfaces of erythrocytes of various mammalian species, rendering the cells susceptible to agglutination by the specific antibacterial serum (see refs. 1, 2). The term 'hæmosensitin' has been suggested for substances which sensitize erythrocytes in this way[3]. This phenomenon has found important practical application in serological technique; but little work has been reported on the mechanism of the fixation process, or on its possible significance in relation either to bacterial disease, to hypersensitivity, or to normal cellular physiology. In this connexion, we have considered it of interest to investigate whether hæmosensitization can take place *in vivo*, and also whether mammalian cell types other than erythrocytes can fix the hæmosensitins.

A polysaccharide preparation (S_t) made from tuberculin by Lamensans, Grabar and Bretey[4] was used as a source of hæmosensitin in these investigations. Antiserum was obtained from rabbits after repeated injections of phenol-killed tubercle bacilli. All sera were heated at 56° C. for 30 min. and afterwards absorbed with an excess of guinea pig erythrocytes before use.

In connexion with the possibility of hæmosensitization existing *in vivo*, it is worth mentioning that *in vitro* the reaction is known to take place much more rapidly at 37° C. than at room temperature, and that it is negligible at 0–4° C. The following experiment was designed to show whether, in fact, the reaction can take place in the animal body. A number of guinea pigs (average weight, 300 gm.) were injected intravenously with different quantities of the polysaccharide ranging from 1 to 20 mgm. dissolved in 2 ml. saline. The controls received saline alone. After three hours, blood was taken from the heart into a sodium citrate solution, washed six times in saline, and the erythrocytes exposed to dilutions of the antiserum and of normal rabbit serum. The antiserum was found to agglutinate the erythrocytes taken from animals which had received 10 and 20 mgm. of polysaccharide, but not those from animals which had received 5 mgm. or less. Erythrocytes taken three days later from the animals which had received 20 mgm. were still sensitive to agglutination, although a higher concentration of antiserum was necessary to produce it. At six days the sensitivity had disappeared. There was no agglutination of the control cells in antiserum or of any of the cells in normal serum. This result demonstrates that hæmosensitization can take place in the blood stream of the living animal in spite of the presence of undiluted plasma, which is known to have a certain inhibitory effect on the reaction *in vitro*.

Leucocytes were used for demonstrating whether other types of cells could also fix hæmosensitins. In a typical experiment, a citrated suspension of guinea pig leucocytes was obtained from a peritoneal exudate after injection 16 hr. previously of 50 ml. Locke's solution. 68 per cent of the cells were polymorphonuclear. The exudate was divided into two portions, to one of which was added polysaccharide to a final concentration of 1 mgm./ml. Both portions were then incubated for 1 hr. at 37° C. and then washed; after resuspension, each was further divided into two parts, which were added respectively to suspensions of normal erythrocytes and of erythrocytes themselves sensitized with the polysaccharide. The resulting suspensions, which were made in normal guinea pig serum, consisted of approximately equal numbers of erythrocytes and white cells. Antiserum was added to a sample of each mixture to a final concentration of 1 per cent, and normal rabbit serum to a second sample. Microscopic examination after 3 hr. at room temperature showed that, in the tube containing leucocytes treated with polysaccharide, sensitized red cells and antiserum, 65 per cent of the leucocytes, comprising both polymorphonuclear and mononuclear cells, were in direct contact with erythrocytes. In the tube containing antiserum and sensitized erythrocytes but in which the leucocytes had not been treated with hæmosensitin, only 9 per cent of the latter were in contact with erythrocytes. In each of the other six tubes in the series, this figure was less than 15 per cent.

Similar experiments have been carried out with suspensions of lymphocytes obtained from lymph glands. For example, in one experiment, 55 per cent of the polysaccharide-treated lymphocytes were found to be incorporated in the clumps of sensitized erythrocytes in the presence of antiserum, whereas in the corresponding tube containing untreated lymphocytes the erythrocyte clumps were virtually free of lymphocytes, only 1 per cent of which were in contact with erythrocytes. Thus, when both leucocytes and erythrocytes are treated with hæmosensitin and are afterwards exposed together to the antibacterial serum, a specific adherence of leucocytes to erythrocytes occurs. This indicates that material of the same antigenic specificity has become fixed on to the surfaces of both types of cell.

Two main conclusions may be drawn from these studies. In the first place, it has been shown that hæmosensitization can take place *in vivo* when a high enough concentration of hæmosensitin is reached in the immediate environment of the cells. Secondly, the ability to fix these substances is not limited to erythrocytes, but is shared by leucocytes, and it seems probable that many other types of cell in the body may be capable of this activity.

This work was carried out in Paris during the tenure of an exchange scholarship of the Medical Research Council and the Centre National de la Recherche Scientifique.

STEPHEN V. BOYDEN

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Sept. 29.

[1] Keogh, E. V., North, E. A., and Warburton, M. F., *Nature*, **161**, 687 (1948).
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Cost of German Medical and Scientific Periodicals

Dr. W. Bonser and Miss Margaret P. Russell have discussed the prices of German medical and scientific periodicals in *Nature* of September 13, 1952, p. 446.

The prices of the periodicals published by the Springer Verlag are fixed in such a way that the number of subscriptions wholly, or at least approximately, covers the costs of production. It is only through subsequent orders that a profit is made. This method automatically leads to a reduction in price when the number of subscribers increases. Thus in July 1952, we announced reduced prices for 1953 for the following periodicals: *Zeitschrift für Physik*, *Zeitschrift für analytische Chemie*, *Biochemische Zeitschrift* (by DM 10 per volume), and *Archiv für experimentelle Pathologie und Pharmakologie* (by DM 8 per volume), that is, some DM 30 less per annum for each of the four periodicals.

A comparison with the cost of periodicals from other countries, particularly from Anglo-Saxon countries, is misleading, for conditions there are quite different.

(1) The number of subscribers is much larger than that to German periodicals. For example, the number of subscribers to the *Zeitschrift für Krebsforschung* is 400, and to *Cancer* 4,000. Our experience is that a reduction in price would not essentially change this proportion. We publish many special periodicals demanding numerous illustrations of high standard, and appealing to only a few hundred subscribers.

(2) Especially in the United States and Great Britain, the periodicals often receive financial support either from scientific societies or universities, or from the Government or from the author himself. For example, in the *Physical Review* and *Journal of Chemical Physics*, the author or his institute has to contribute 15 dollars per page. For the *Journal of Neuropathology* the author is not reimbursed for his expenses nor does he receive free separate prints, but is asked to answer for part of the costs of production.

With reference to particular points made by Dr. Bonser and Miss Russell, we wish to make the following comments:

(1) *Annual cost.* Since 1933, foreign libraries have received price lists every year showing the maximum cost for the coming year.

(2) With the exception of one Swiss journal erroneously mentioned, the list supplied to us by Dr. Bonser and Miss Russell in which Springer periodicals are compared with periodicals of other German publishing houses contains only periodicals which are published—or at least printed—in the Eastern Zone of Germany, where the costs of production are at most one-half as high, not considering the difference in currency exchange.

(3) The tables of the detailed list which Dr. Bonser and Miss Russell were kind enough to let us have can scarcely be considered as a basis, in so far as (*a*) a comparison is made not of the prices per sheet but of the total prices without regard to number of pages and get-up (number and quality of illustrations); (*b*) devaluation of sterling is mentioned but not allowed for in the tables; (*c*) it was due to measures (now abandoned) taken by the German Government to promote export that, during 1935–45, selling prices abroad were 25 per cent lower than on the home market.

Springer periodicals are published at the expense and risk of the publishing house alone. Costs of production of West German publishing houses had risen in 1949 to two and a half times the pre-war level and are now three times as high. The prices per sheet of Springer periodicals, on the other hand, average only twice as high as before the War.

SPRINGER VERLAG

Neuenheimer Landstrasse 24,
Heidelberg.

WE wish to make the following reply to some of the points in the above letter from the Springer Verlag. It quotes from the fuller version of our paper, necessarily condensed in *Nature*, but now widely circulated.

The primary fact that the cost of German, and especially of Springer's, periodicals is far in excess of that of other countries still holds. The reduction in their sales which is likely to result must prove detrimental, scientifically as well as financially, to German progress.

The Springer Verlag points out that its periodicals are completely its own financial venture. We have already suggested, in our fuller paper, that a solution to the problem might be a change-over of responsibility to the German societies concerned, as has been done for certain publications in Great Britain and the United States.

We should like to reply to the following comments on details.

(2) The Swiss journal (*Annales Pædiatrici*) was not "erroneously mentioned" but was intentionally included, since it is the continuation of the German journal *Jahrbuch für Kinderheilkunde*, both of which have the same publisher now in Basle but formerly (until the end of 1938) in Berlin.

(3*a*) We actually did compare two journals from the point of view mentioned, namely, the *British Journal of Experimental Pathology* and the *Archiv für experimentelle Pathologie*, to the great disadvantage of the Springer periodical; (3*b*) it was pointed out that devaluation of sterling amounted to 45 per cent for American and only 26 per cent for German periodicals—the figures presented in our table are the resultant prices paid by us.

We feel that our table of comparisons still stands as a summary of facts, and we still hope that some means of reducing the cost of these essential contributions to knowledge, so as to be comparable with those of other German firms, may be possible.

WILFRID BONSER
MARGARET P. RUSSELL

Medical School,
University of Birmingham.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 2

Society of Chemical Industry, London Section (joint meeting with the Institute of Petroleum, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 10 a.m.—Symposium on "Production and Utilization of Petroleum Raw Materials in the U.K. Chemical Industry".

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Annual General Meeting.

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. L. Boucher and Mr. D. Bagley: "Developments in the Recovery of By-Products from Coke Oven Gases".

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Unsold: "Some Recent Progress in Astrophysics".* (Further Lecture on March 4.)

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. H. C. Longuet-Higgins: "Matter". (Inaugural Lecture in the Chair of Theoretical Physics.)*

Tuesday, March 3

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. R. Jonckheere: "Recent Experiments in the Psychology of Learning".*

Society of Public Analysts and Other Analytical Chemists, Physical Methods Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Absorptiometry Meeting.

Sheffield Metallurgical Association (in the Grand Hotel, Sheffield), at 7 p.m.—Mr. D. R. O. Thomas: "Technological Education in relation to the Iron and Steel Industry".

Society of Cosmetic Chemists of Great Britain (at the British Colour Council, 13 Portman Square, London, W.1), at 7 p.m.—Mr. J. K. Barraclough: "Dyes".*

Wednesday, March 4

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. C. B. Frisby: "The Assessment of Suitability for Employment".

Thursday, March 5

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Harold Hartley, F.R.S.: "Sir Humphry Davy, Bt., P.R.S." (Wilkins Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Lawrence Bragg, F.R.S.: "X-Ray Optics". (Further Lectures on March 12, 19 and 26.)

British Institution of Radio Engineers, Scottish Section (in the Lecture Theatre, The University, Glasgow).—Dr. J. M. Reid: "Electronics in Nuclear Research".

Friday, March 6

Institution of Mechanical Engineers (joint meeting with the Steam Group, at Storey's Gate, St. James's Park, London, S.W.1), at 10.30 a.m.—Series of Papers from the Parsons and Marine Engineering Turbine Research and Development Association dealing with Steam Turbine Research and Development work carried out at their Research Station.

Society of Public Analysts and Other Analytical Chemists (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 2.45 p.m.—Annual General Meeting; at 3.15 p.m.—Dr. J. R. Nicholls: Presidential Address.

Royal Institute of Philosophy (at University Hall, 14 Gordon Square, London, W.C.1), at 5.30 p.m.—Mr. Meyrick H. Carré: "Poetry and Philosophy".

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. G. F. Marrian, F.R.S.: "Some Aspects of the Metabolism of the Steroid Hormones".*

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. R. V. Jones: "The Pressure of Radiation".

Saturday, March 7

Nutrition Society (at King's College of Household and Social Science, Campden Hill Road, London, W.8), at 10.15 a.m.—Symposium on "Education in Nutrition in the United Kingdom".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. John Layard: "The Journey of the Dead in Malekula, New Hebrides".*

Joint Biology Committee and the Association of Agriculture (at University College, Gower Street, London, W.C.1).—Conference on "Plant and Animal Breeding".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Agricultural Chemistry—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh (March 7).

Scientific Officers (Grade 3) and Scientific Officers (Grade 1) for research and development in (*a*) radio transmission and reception at high and ultra-high frequencies, (*b*) modulation methods and terminal equipment, and theory connected therewith, (*c*) electronic and electromechanical equipment for computing and recording, and Experimental Officers (Grade 3) and Experimental Officers (Grade 1) for research or development associated with (*a*) radio transmission and reception at high and ultra-high frequencies, (*b*) modulation methods and terminal equipment, (*c*) electronic and electro-mechanical equipment for computing and recording; at the Electronic Research Laboratory, Salisbury, Australia—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (March 7).

Biochemist at the Southport General Infirmary—The Secretary, Southport and District Hospital Management Committee, Promenade Hospital, Southport (March 9).

Demonstrator or Assistant Lecturer in the Department of Physics—The Secretary, Bedford College, Regent's Park, London, N.W.1 (March 9).

Deputy Director of Research—The Director of Research, British Leather Manufacturers' Research Association, Milton Park, Egham (March 9).

Lecturer in the Department of Mining and Geology—The Principal, Wigan and District Mining and Technical College, Wigan (March 9).

Assistant Lecturer in Engineering (with qualifications in civil engineering, with special interests in structures or hydraulics)—The Registrar, The University, Manchester 13 (March 11).

Head of the Department of Physics, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 12).

Lecturer in Medical Statistics—The Registrar, The University, Manchester 13 (March 12).

Chemical Engineers, Mechanical Engineers, Metallurgists, Theoretical Physicists, Chemists, and Physicists (Senior Principal Research Officer, Principal Research Officer, Senior Research Officer and Research Officer grades) in the Commonwealth Scientific and Industrial Research Organization, for research in the field of development of atomic energy as a source of industrial power—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4157 (March 14).

Research Workers (2, one with zoological, the other with botanical training) to establish a unit for the study of the ecology of polluted rivers and streams—The Director, Freshwater Biological Association, The Ferry House, Far Sawrey, Ambleside, Westmorland (March 14).

Analyst (with sound experience in the analyses of fertilizers, soils and other agricultural materials) in the Department of Chemistry—The Registrar, Wye College, Wye, Ashford, Kent (March 16).

Botanist (Assistant Lecturer grade) in the Marine Biology Station—The Secretary and Registrar, University College of North Wales, Bangor (March 17).

Assistant Lecturer in Mathematics (with special qualifications in applied mathematics)—The Registrar, The University, Manchester 13 (March 18).

Head of the Department of Mechanical Engineering—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (March 26).

Head of the Department of Mathematics, and a Lecturer or Assistant Lecturer in Chemistry (preferably in physical inorganic chemistry), at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 21).

Agricultural Officer (with degree in agriculture or equivalent, with at least two years postgraduate experience) in Sarawak, for extension and investigational work in a district under fairly strenuous conditions—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/24/02.

Agriculturist (with degree in agriculture or horticulture and, preferably, with knowledge of commercial date cultivation) in the Somaliland Protectorate, to take charge of experimental scheme for date cultivation with a view to its eventual expansion—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CSC.63/5/01.

Chemist (with good honours degree in chemistry or agricultural chemistry, and postgraduate research experience, preferably in soil science) in the Department of Science and Agriculture, Barbados, for investigational and advisory work on soils, soil survey and analysis, manurial trials, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/28/01.

Civil Engineers in various branches of the Public Works Department in Nigeria, for general civil engineering, irrigation projects, rural and urban water supplies, road development, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/14/03.

Meteorologist (with a first- or second-class honours degree in mathematics or physics) in Nigeria, for meteorological forecasting, research, climatology and administrative duties involved in the organization of the Service—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.57/14/01.

Science Graduate (preferably with some research, production, or information experience) as scientific assistant in the Information Department—The Information Officer, British Scientific Instrument Research Association, Sira, Southill, Elmstead Woods, Chislehurst, Kent.

Senior Lecturer in Chemical Engineering—The Principal, West Ham College of Technology, Romford Road, London, E.15.

Teaching and Research Assistants (part-time) in the Department of Physics—Dr. A. B. McLay, Chairman of the Physics Department, Hamilton College, McMaster University, Hamilton, Ont., Canada.

Zoologists (with good honours degree in zoology, and at least two years postgraduate experience) in the East African Tsetse and Trypanosomiasis Research and Reclamation Organization, for research into distribution and behaviour of tsetse fly and their ecological background—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.77/88/01.

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LECTURES AND COURSES

UNIVERSITY OF LONDON

A course of three lectures entitled "Some Problems in Thermodynamics and Refrigeration," will be given by Professor R. Plank (Karlsruhe), at 5.30 p.m., on March 9, 11, and 13, at King's College, Strand, W.C.2.

Admission free, without ticket.

JAMES HENDERSON,
Academic Registrar.

UNIVERSITY OF LONDON

A course of two lectures will be delivered by Professor S. Bergström (Lund), at 5.15 p.m., on March 9 and 12, at Bedford College, Regent's Park, N.W.1. March 9: "Intestinal Absorption of Fats"; March 12: "Formation and Interconversion of Bile Acids."

Admission free, without ticket.

JAMES HENDERSON,
Academic Registrar.

OFFICIAL APPOINTMENTS

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18 to 64 inclusive, or a woman aged 18 to 59 inclusive, unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

NOTTINGHAM NO. 2 HOSPITAL MANAGEMENT COMMITTEE

Applications are invited from science graduates for the appointment of a Biochemist within the Nottingham No. 2 Group of Hospitals. The person appointed will work under the direction of the Chemical Pathologist at the City Hospital, where there is a fully equipped biochemical laboratory. Salary in accordance with experience and qualifications, based on Whitley Council scales, within the range of £425 to £730 per annum.

Applications, stating experience and qualifications, together with the names of two persons to whom reference can be made, should be sent to the undersigned.

J. H. HARGREAVES,
Group Secretary.

Sherwood Hospital,
Hucknall Road, Nottingham.

THE BRITISH LEATHER MANUFACturer's Research Association invites applications for the post of Deputy Director of Research. Applicants should have good academic qualifications in either chemistry or physics and have had several years' research experience, not necessarily in applied research. The leather producing industry is primarily a fibre industry, and research experience in the chemical and physical properties of fibres would be an advantage. The Association, formed in 1920, has a staff of 60, which includes biologists, chemists, engineers, and physicists. The commencing salary will be £1,500 per annum, increasing by normal annual increments of £100 to £2,000, and will carry benefits under the F.S.S.U. scheme.—Applications, giving full details of qualifications, experience and names of two referees, should reach the Director of Research, Dr. H. Phillips, B.L.M.R.A., Milton Park, Egham, by Monday, March 9.

REQUIRED, PHYSICIST WITH MATHEmatical leanings, to continue experimental and theoretical work on fibre assemblies. Research training or experience necessary. Salary in accordance with age and experience. Superannuation under the Federated Superannuation System for Universities.—Apply to the Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

THE BRITISH RAYON RESEARCH ASSOciation requires the services of ten Physicists, for research work on problems arising out of the normal textile operations. Applicants must have had sound research training. Salary in accordance with age and experience. Superannuation under the Federated Superannuation System for Universities.—Apply to the Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

THE BRITISH RAYON RESEARCH ASSOciation requires the services of a Physical Chemist, for work on the oxidation of cellulosic materials. Salary in accordance with age and experience. Superannuation under the Federated Superannuation System for Universities.—Apply to the Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

UNIVERSITY OF EDINBURGH
DEPARTMENT OF PUBLIC HEALTH AND SOCIAL MEDICINE

Applications are invited for the post of Assistant in the Department of Public Health and Social Medicine from graduates in medicine, biology, psychology, sociology, or any other social science. Among the duties of the successful applicant will be participation in the research programme of the Senior Lecturer in Social Biology on the Social Biology and Social Medicine of the Ageing Population. Salary scale £450 by £50 to £550 per annum, with superannuation benefit and family allowance where applicable.

Applications, with testimonials and including the names of two referees, should be lodged with the undersigned, from whom further particulars may be obtained.

CHARLES H. STEWART.
Secretary to the University.

MAKERERE COLLEGE
THE UNIVERSITY COLLEGE OF EAST AFRICA

Applications are invited for the Headship of the Department of Mathematics. Salary on professorial scale £1,320 by £50 to £1,430 or Readership scale £1,100 by £50 to £1,300 per annum. Status and point of entry in scale dependent upon qualifications and experience. Cost of living allowance £300 per annum, family allowance £50 per annum per child (maximum £150 per annum). F.S.S.U. Part-furnished accommodation at rent not exceeding 10 per cent of basic salary. Free passages (including families) on appointment, termination, and leave (three months every two years).

Applications (six copies), giving full particulars of qualifications and experience, and the names of three referees, should be sent to the Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, W.C.1, from whom further particulars may be obtained. Closing date March 21, 1953.

MAKERERE COLLEGE
THE UNIVERSITY COLLEGE OF EAST AFRICA

Applications are invited for the post of Lecturer or Assistant Lecturer in Chemistry, preferably in physical or inorganic chemistry. Salary for lecturer on the scale £695 by £25 to £770 by £30 to £890 per annum; Assistant Lecturer on the scale £620 by £25 to £670 per annum. There is a temporary cost of living allowance of 30 per cent of salary (maximum £300 per annum), F.S.S.U., child allowance £50 per annum (maximum £150). Status and point of entry determined by qualifications and experience. Partly furnished quarters at not more than 10 per cent of salary. Free passages (including family) on appointment, termination, and leave (three months every two years).

Applications (six copies), giving names of three referees and full particulars of qualifications and experience, to the Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1, from whom further particulars may be obtained. Closing date March 21, 1953.

AUSTRALIAN NATIONAL UNIVERSITY
CANBERRA, AUSTRALIA
JOHN CURTIN SCHOOL OF MEDICAL RESEARCH

Applications are invited for appointment to Research Fellowships in the Department of Biochemistry in Canberra. The salary range for Research Fellows is £A.890 to £A.1,090 per annum, to which a cost of living adjustment, at present £A.180 per annum, is added. The university operates a superannuation scheme based on the F.S.S.U. pattern, and reasonable travel and removal expenses to Canberra will be paid. The tenure of Research Fellowships is three years, renewable to five years. Research Fellows may be promoted in due course to Senior Research Fellowships. Applicants must be university graduates with at least two years' experience in research and must have a Ph.D. degree or its equivalent.

Conditions of appointment may be obtained from the Secretary, London Office of The Australian National University, 27 Russell Square, London, W.C.1, with whom all applications (in duplicate), should be lodged by March 30, 1953. Applications should include age, nationality, marital status, war service (if any), academic qualifications and experience, a list of published papers and papers in the press, and the names and addresses of three referees.

R. A. HOHNEN,
Registrar.

H.M. COLONIAL SERVICE

Applications are invited for the following posts:

A vacancy exists for a Meteorologist in Nigeria (CDE.57/14/01). Appointment is on probation to the pensionable establishment with salary in the scale £570 to £1,290 per annum plus expatriation allowance of between £180 and £270 per annum. An outfit allowance is payable. Income tax at low local rates. Quarters are provided when available, at a rental of 10 per cent of basic salary. Free first-class passages for officer and wife once each way each tour. Special regulations for children's passages. Free medical attendance for officer and family whilst in the Colony. Vacation leave at the rate of seven days for each month of resident service. Candidates must possess a first- or second-class honours degree in mathematics or physics. Professional experience desirable, but candidate with no previous experience would, if selected, be given a course of training prior to taking up appointment. Duties consist of meteorological forecasting, research, climatology and administrative duties involved in the organization of the Service.

Chemist, Department of Science and Agriculture, Barbados (CDE.63/28/01) for investigational and advisory work on soils, soil survey and analysis, manurial trials, etc. Candidates should possess good honours degree in chemistry or agricultural chemistry and postgraduate research experience, preferably in soil science. Appointment pensionable in salary scale £860 to £1,200 per annum plus temporary cost-of-living allowance at present £32 10s. per annum. All reasonable expenses incurred on first appointment payable up to sum not exceeding £300. Free leave passages for officer and wife at end of tour of service of three and a half years. Appointment may be made on agreement for three years if necessary, with passage expenses payable for officer and family on appointment and completion of agreement, not exceeding £300 each way.

Agricultural Officer, Sarawak (CDE.63/24/02) for extension and investigational work in a district under fairly strenuous conditions. Candidates must possess degree in agriculture or equivalent with at least two years' postgraduate experience and be active and fit. Appointment pensionable in salary scale £630 to £1,260 per annum, plus expatriation allowance £210 to £245 per annum and local cost of living allowance. Outfit allowance £60 for officer entering basic scale below £980 per annum. Free passages on appointment and leave for officer, wife and up to three children under 10 years of age. Government quarters when available at rental of £21 to £84 per annum. Free medical attention. Taxation at local rates.

Zoologists, East African Tsetse and Trypanosomiasis Research and Reclamation Organization (CDE.77/88/01), for research into distribution and behaviour of tsetse fly and their ecological background, involving much field work. Candidates must be between 23 and 35 years of age, preferably unmarried and possess good honours degree in zoology, and at least two years' postgraduate experience. They should have some knowledge of botany, chemistry or agriculture and of the conducting of ecological investigations. Appointments on probation in Colonial Research Service in Scientific Officer scale £400 to £650 or Senior Scientific Officer scale £750 to £950, according to age and experience. In addition, overseas research allowance £100 to £220 per annum, cost-of-living allowance at present 25 per cent basic salary, plus overseas research allowance and outfit allowance £60. Contributory superannuation scheme. Taxation at local rates. Free passages on appointment and leave. Candidates not accepted on these terms may be considered for a short-term appointment.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number shown against the post applied for.

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

Applications are invited for the appointment of Junior Lecturer in the Department of Entomology. The appointment will be for a period of two years in the first instance, with the possibility of an extension for a further year. The person appointed will be required to carry out teaching and research work under the direction of the Head of the Department. Salary, £600 by £50 to £700.

Applications, stating age, qualifications (with dates), and previous experience, should be sent to the Assistant Dean, London School of Hygiene and Tropical Medicine, Keppel Street, (Gower Street), London, W.C.1, not later than May 31, 1953.

THE DEFENCE RESEARCH BOARD

requires

A SCIENTIST

for

OPERATIONAL RESEARCH

Requirements:

Positions are open in Ottawa and elsewhere for research scientists in the field of operational research and systems analysis. Work will be of such a nature that the applicant should be capable of conducting his own research with a minimum of supervision. Initial indoctrination instruction will be given.

Qualifications:

M.A., M.Sc., or Ph.D. or equivalent in one of the physical sciences, mathematics, bio-mathematics, or mathematical economics, preferably with some industrial or laboratory research experience.

Salary:

Initial salary up to $6,000 per annum depending on qualifications and experience.

Generous holiday and sick leave privileges, superannuation, medical and hospital insurance plans in effect.

Applications should be forwarded to the Director, Research Personnel, Defence Research Board, Department of National Defence, "A" Building, Ottawa.

All replies will be regarded as confidential.

UNIVERSITY OF GLASGOW

LECTURESHIP IN CHEMISTRY

Applications are invited for a Lectureship in Chemistry, tenable from October 1, 1953. Applicants should have special interests in some branch of electro-chemistry. Salary scale £500 to £1,100. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (five copies), should be lodged, not later than March 31, 1953, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court

NATIONAL INSTITUTE OF AGRICULTURAL BOTANY

Regional Trials Officer required for work possibly at Cambridge. Salary scale £520 to £835 per annum, plus pay addition of 10 per cent on the first £500 and 5 per cent on the remainder. Superannuation under the Federated Superannuation System for Universities. Degree in botany or agriculture or equivalent qualification, with practical experience in crop production required.

Application form and further particulars from M. G. Tozer, Secretary, N.I.A.B., Huntingdon Road, Cambridge.

UNIVERSITY OF SOUTHAMPTON

Assistant Technician required in Botany Department. Salary scale £234 by £18 to £378.

Applications should be made, in writing, to the Professor of Botany.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

An Assistant Lecturer in Organic Chemistry is required in October, 1953. Applicants should hold a higher degree and preferably should have post-doctorate research experience in organic chemistry. They should not be liable for National Service. The starting salary will be in the range £500 to £600, according to age and experience.

Applications, with the names of two referees, should reach Professor R. P. Linstead, C.B.E., F.R.S., Organic Chemistry Department, Imperial College of Science and Technology, London, S.W.7, not later than May 1.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

ST. JOHN'S, NEWFOUNDLAND, CANADA

Applications are invited from qualified persons to fill the now vacant positions of

Associate Professor of Chemistry (Organic).
Associate Professor of Chemistry (Physical).

The duties of the successful applicants will be to teach in undergraduate courses generally to the requirements of the degrees of B.A., and B.Sc., and to establish courses of instruction leading to the degree of M.Sc.

The stipend, for applicants holding the degree of M.Sc., is $4,300 to a maximum of $4,800 after five years' service, and for those with the degree of Ph.D., $5,000 to $5,500. Equivalent training may be accepted in lieu of either degree. The University pays for travelling to a maximum of $750 for each appointee. A comprehensive contributory pension scheme, and illness benefit are optional.

Duties of instruction are normally such that appointees will have time available to carry on their own research problems.

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

The Governing Body invites applications for the post of Head of the Physics Department, rendered vacant by the appointment of Dr. G. O. Stephens, B.Sc., Ph.D., F.Inst.P., to the Principalship of North-East Essex Training College. Duties will commence on September 1, 1953, or as soon as possible thereafter. Candidates should possess a good honours degree in physics, together with a research degree, the Fellowship or Associateship of the Institute of Physics, and teaching experience, preferably in a technical college or university. The salary scale will be Burnham Grade II (£1,040 by £25 to £1,190).

Further particulars and application form will be sent by the undersigned on receipt of a stamped, addressed, foolscap envelope. Applications not on the form provided will be disregarded. Last date for receipt of applications, Friday, March 13, 1953.

E. C. SMITH,
Principal.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for the following appointments: (i) Lecturer in Mechanical Engineering (Grade I). Salary scale £1,100 to £1,300. A good honours degree in engineering, research and industrial experience. (ii) Lecturer in Mechanical Engineering (Grade II). Salary scale £550 to £1,100. A good honours degree in engineering, practical training and/or research experience. Initial salary according to qualifications and experience, but for Grade II appointment not higher than £900.

Form of application and conditions of appointment may be obtained from the undersigned.

H. PICKBOURNE,
Registrar.

UNIVERSITY OF GLASGOW

LECTURESHIP IN AGRICULTURAL CHEMISTRY

Applications are invited for a Lectureship in Agricultural Chemistry, tenable from October 1, 1953. Applicants should preferably have special interests in soil science or plant nutrition. Salary scale £550 to £1,100. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (six copies), should be lodged, not later than March 31, 1953, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

NOTTINGHAM NO. 1 HOSPITAL MANAGEMENT COMMITTEE

HOGARTH RADIOTHERAPEUTIC CENTRE GENERAL HOSPITAL, NOTTINGHAM

Applications are invited for the post of Senior Physicist at the above centre. Candidates must have an honours degree in physics and must have had previous hospital physics experience. Salary in accordance with the Whitley Council scales. Further details of the post can be obtained from the Medical Director.

Applications should be forwarded as soon as possible to the undersigned, stating qualifications and experience, and giving the names of two referees.

H. M. STANLEY,
Group Secretary.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF PHARMACY

Applications are invited for the appointment of Assistant Lecturer in Physiology and Pharmacology in the above Department. Salary scale £450 by £50 to £550.

Form of application and further particulars may be obtained from the undersigned.

H. PICKBOURNE,
Registrar.

SCHOOL DISTRICT OF WINNIPEG NO. 1

WINNIPEG, CANADA

Applications are invited for the position of Principal for the Technical-Vocational High School in the City of Winnipeg to begin the school term, September 1, 1953.

This School, presently enrolling about 900 students and with a capacity of 1,200 to 1,500 students, is a senior high school with pupils in grades ten to twelve. The students spend half their time taking academic instruction and the other half taking technical instruction. The Principal has responsibility for the general direction of the evening school programme. In his duties the Principal is assisted by a vice-principal and by a principal of the evening school. Applicants should have an industrial background, considerable administrative experience in education, and an intimate knowledge of the whole field of technical education. The salary is $6,000 by $150 to $6,700, plus any cost-of-living adjustment that may be payable (at present $86 per annum). The school district maintains a pension fund with the rate of employees' contributions based on age up to a maximum of 7.5 per cent. Reasonable travelling expenses will be allowed.

Applicants should state their age, give full details of their training and experience, and include the names of at least three references. One copy of the letter of application should be submitted direct to Mr. F. A. Allden, Secretary-Treasurer, School District of Winnipeg, Winnipeg, Manitoba, Canada, by April 1, 1953, and two copies to the Secretary, the Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, by the same date.

UNIVERSITY OF CAMBRIDGE

Applications are invited for a University Demonstratorship in Physics. The demonstrator will hold office from October 1, 1953, and applications close on Saturday, March 21, 1953.

Details of duties, salary, etc., may be obtained from Dr. F. B. Kipping, Chemical Laboratory, Cambridge.

MIDDLESEX HOSPITAL MEDICAL SCHOOL

FERENS INSTITUTE OF OTO-LARYNGOLOGY

Technician for mechanical work with workshop experience. A knowledge of electronics an advantage but not essential. Salary on scale £410 to £475 per annum, plus London weighting, family allowances and superannuation.

Applications to Secretary, Ferens Institute, Middlesex Hospital Annexe, Cleveland Street, W.1.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Engineering. Candidates should have qualifications in civil engineering, with special interests in structures or hydraulics. Salary not less than £450 per annum, with membership of F.S.S.U. and children's allowance scheme.

Applications should be sent not later than March 11, 1953, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

H.M. COLONIAL SERVICE

Applications are invited for the following post: Research Assistant, Department of Tsetse Control, Gold Coast (27059/311), to compile and analyse data on tsetse incidence with the purpose of evaluating the necessity for various control methods and of studying the biology of tsetse species in order to develop new control methods. Candidates must possess honours degree in biology with experience of or inclination towards mathematical aspects of biological problems. Appointment either on contract for two tours of service of twelve to twenty-four months each in salary scale £990 to £1,950 per annum, with gratuity of £25 to £37 10s. for each completed three-month period of satisfactory service or pensionable in salary scale £650 to £1,280 per annum, plus overseas allowance £175 to £350 per annum. Contract appointment would be in Gold Coast Local Civil Service. Outfit allowance £30 to £60. Government quarters, if available, at rental of £60 to £90 per annum. Taxation at local rates. Free first-class passages on appointment and leave for officer, wife, and up to three children under the age of 13.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number (27059/311).

LABORATORY TECHNICIAN REQUIRED to assist in biological research in the Pollards Wood Research Station (Chalfont St. Giles, Bucks), of the Institute of Cancer Research (Royal Cancer Hospital). Previous experience in histological technique preferred, but not essential. Salary according to age, experience, and qualifications.—Applications should be addressed to reach the Secretary, The Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3, on or before March 16, 1953, marking the envelope "Technician Pollards Wood."

AVAILABLE AT THE CHEMICAL ENGINeering Department, Imperial College: (1) A Bursary of £300 per annum for a student with at least a second honours degree, to work for a Ph.D. degree on an interesting problem in the physical chemistry of heterogeneous catalysis. (2) A salary of up to £450 per annum for a Research Assistant to study the physical chemistry of an important industrial reaction.—Science graduates should apply to the Registrar, Imperial College, London, S.W.7, stating qualifications.

THE BRITISH PAPER AND BOARD INdustry Research Association invite applications for chemists or chemical engineers for the post of Research Officer. Starting salary £500 to £650, according to qualifications and experience, with F.S.S.U. provision. Candidates should possess a first- or second-class honours degree or an Associateship of the Royal Institute of Chemistry. The work will be concerned initially with the processing of fibrous raw materials and recovery or disposal of waste products. Opportunities will be provided for gaining experience of commercial paper and board manufacture, and the successful candidate may be asked to spend short periods at mills investigating particular problems.—Please apply to The Director, Welcomes Road, Kenley, Surrey.

AVON AND DORSET RIVER BOARD

ASSISTANT INSPECTOR OF FISHERIES AND POLLUTION

Applications are invited from suitably qualified persons for the above whole-time appointment. The conditions of service will be those of the National Joint Council for Local Authorities, Administrative, Professional, Technical, and Clerical Services, and the salary scale will be £465 per annum, rising to £510 per annum (APT Grade D, according to qualifications and experience. Travelling and subsistence allowances will be paid according to the scale in force from time to time. Applicants, who will be required to work under the direction of the Inspector of Fisheries and Pollution, should not be less than 25 years of age, and should preferably have experience in natural science with zoology as a main subject. The appointment will be subject to the provisions of the Local Government Superannuation Act, 1937, and the appointment will be terminable by one month's notice on either side. The successful candidate will be required to pass a medical examination, to reside in the Bournemouth area, and should possess a car or motor-cycle combination.

Applications, giving particulars of age, education and previous experience, together with copies of not more than three recent testimonials must be delivered to the undersigned not later than Saturday, March 14, 1953.

D. W. TREADGOLD,
Clerk to the Board.

Rostherne,
3 St. Stephen's Road,
Bournemouth.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for the following posts: (i) A probationary Assistant Lectureship in Geography, salary not less than £450 per annum. (ii) Either a probationary Assistant Lectureship in Education (salary not less than £450 per annum), or a Lectureship in Education (salary on the scale £550 by £50 to £1,100 per annum). Applicants should be able to undertake lectures in methods of teaching biology and/or chemistry.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications must be sent by March 21, 1953.

MINISTRY OF SUPPLY, ROYAL AIRCRAFT Establishment, Farnborough, has Experimental Officer class vacancies in Guided Weapons Department, for work on design, development, and performance of new weapons and associated guidance and control systems; instrumentation of flight trials and investigation of trials results. Experience in any of these fields desirable: light engineering development, hydraulic and servo mechanism design, electrical control devices, centimetric radar techniques, design of light electrical, electronic or optical mechanisms, aircraft design, ballistics or aerodynamics, scientific computing or design of high-speed computing machines. Qualifications, higher school certificate (science), or equivalent, but further qualifications in mechanical, electrical or electronic engineering, physics or mathematics may be an advantage. Salaries within ranges, Experimental Officer (minimum age 26), £597 to £754, Assistant Experimental Officer, £264 (age 18) to £555. Women somewhat less. Posts unestablished.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.508/52A. Closing date March 14, 1953.

MINISTRY OF SUPPLY, R.A.E., FARNborough, Hants, requires Electrical or Mechanical Engineer as Scientific Officer for research and development in connection with generation, conversion, and control of electric power for aircraft. Work includes planning of general layout of aircraft supply system, design, and development of rotating machinery and associated control equipment to meet special conditions of operation encountered in modern aircraft and guided missiles, and allows considerable scope for originality in devising associated equipment. Qualifications, first- or second-class honours degree or equivalent in engineering or in physics or mathematics with subsequent electrical engineering experience. Experience of original work in design of dynamo electrical machinery may be advantage. Salary within range, £417 to £675. Women somewhat less. Post unestablished. F.S.S.U. benefits may be available.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.54/53A. Closing date March 14, 1953.

COMMONWEALTH of AUSTRALIA

APPOINTMENT NO. 3883 OF CYTOLOGIST

The Commonwealth Scientific and Industrial Research Organization invites applications for appointment of a Cytologist to the Division of Plant Industry, Canberra, A.C.T. Duties, to assist the chief of the division in genetical and cytological investigations. Qualifications, university degree in science or other relevant qualifications or experience. Salary, within the range of £A.800 to £A.1,088 per annum, ten increments. Salary includes a cost of living adjustment of £A.180 per annum. Fare to Australia (including those of wife and family) will be paid. Appointee may be granted superannuation privileges.

Application, referring to appointment No. 3883, and stating full name, place and date of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by names and addresses of at least two persons willing to act as referees, if so desired, and copies of not more than four testimonials, should reach the undersigned (from whom further particulars may be obtained), by March 28, 1953.

J. E. CUMMINS,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House,
Kingsway, London, W.C.2.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Mathematics. Candidates should have special qualifications in applied mathematics. Salary not less than £450 per annum, with membership of F.S.S.U. and children's allowance scheme.

Applications should be sent, not later than March 18, 1953 to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

TRINIDAD, B.W.I.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

Applications are invited for appointment as Junior Plant Physiologist under the Colonial Development and Welfare Cocoa Research Scheme. Emoluments in the scales for Scientific Officer or Senior Scientific Officer, with an overseas research allowance and a local variable cost of living allowance. Superannuation (and continuity of pensionable service for a member of the Colonial Service). If unfurnished quarters are provided a rent of 8 per cent of basic salary is payable. If furnished, 10 per cent. Liberal leave and passage arrangements. Applicants must have a good honours degree in botany, with special reference to plant physiology, and preferably some postgraduate experience. Students taking their final degree examinations in June, 1953, may submit provisional applications. Previous knowledge of cocoa or of tropical agriculture is not essential.

Applications must be submitted before April 30, to the Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2, from whom further particulars can be obtained. Overseas candidates may apply by telegram if written application follows immediately by airmail. The names of at least two referees should be submitted.

ASSISTANT WORKS MANAGER REQUIRED for atomic energy factory at Salwick, near Preston, to be responsible for operation of chemical plants. Qualifications, honours degree in chemistry or chemical engineering, A.R.I.C., A.M.I.Chem.E., or equivalent. Considerable operational experience in a large chemical factory, familiarity with wide variety of plant control instruments, sound knowledge of dealing with toxic hazards, and knowledge of cost control essential. Salary £1,256 to £1,454. Voluntary superannuation. House within reasonable time, if married.—Applications to Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, quoting 425.

MINISTRY OF LABOUR AND NATIONAL Service requires an Agriculturalist (unestablished) at the Technical and Scientific Register. Qualifications, degree in agriculture, preferably with technical, industrial, or administrative experience, preferably male and over 25 years. Duties, finding suitable employment for graduates in agriculture and related subjects. Salary dependent upon age and experience within range (approx.) £357 to £715 (£467 at 25) (men).—Write for application forms to Ministry of Labour and National Service (K Section), Almack House, 26 King Street, London, S.W.1, quoting reference G6/53A. Closing date March 14, 1953.

H.M. COLONIAL SERVICE

Applications are invited for the following posts: Vacancies exist for Geologists in Malaya (CDE.105/60/03). Candidates, under 30, must possess as minimum qualifications a first- or good second-class honours degree in geology. Duties involve investigation of mineral resources and detailed geological mapping. Laboratory work will deal mainly with petrology and economic mineralogy. Appointment is on probation to the permanent and pensionable establishment. The consolidated salary scale (basic salary, plus expatriation allowance) is £820: £870: £1,005 by £50 to £1,408: £1,479: £1,563: £1,635: £1,685: £1,764 by £59 to £2,044 per annum approximately. A variable cost of living allowance, according to family commitments, is also payable. Quarters, when available, at a rental of between £21 and £84 per annum; free passages for officer and wife up to three children under the age of 10; free medical attendance for officer and family whilst in colony; vacation leave four days for each completed month of resident service.

Fisheries Officer, Gambia (CDE.65/12/01) to improve fishing methods, train local fishermen, and organize marketing of fish. Candidates should possess degree or diploma in zoology or allied subject and have some experience of marine biology and fishing craft. A candidate otherwise qualified who lacks experience in fisheries work might be selected, subject to subsequent training. Appointment pensionable in salary scale £510 to £1,000 per annum, plus expatriation allowance £150 to £300 per annum and temporary non-pensionable allowance at present £110 per annum. Outfit allowance £60. Government quarters when available at rental of £60 to £90 per annum. Free first-class passages on appointment and leave for officer and for wife, and up to two children under 16 years of age if permission granted for them to proceed to Colony. Taxation at local rates.

A vacancy exists for a Chemist-Assayer (27106/57/52) in Northern Rhodesia. The appointment is on agreement for one tour of three years in the first instance with salary in the scale £690 to £1,320, according to qualifications and experience. In addition a cost of living allowance of 21 per cent of salary is payable. Income tax at low local rates; water, light, and sanitary fees also payable; rent for Government quarters with heavy furniture, when available, not more than 10 per cent of salary; free passages for officer, wife, and up to the cost of one adult return passage for children; free medical attention for officer and family within Northern Rhodesia; five days vacation leave for each completed month of resident service. Candidates, preferably between 25 and 30 years of age, should possess an honours degree in chemistry and would be required to undergo two years' special postgraduate training before taking up appointment. Duties will be to carry out assays and analyses of ores, minerals, and rocks in the laboratory of the Geological Survey Department.

Apply in writing, to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications, and experience. Mention the reference number shown against the post applied for.

H.M. COLONIAL SERVICE

Applications are invited for the following post: Game Warden, Federation of Malaya (CDE.152/60/01). Candidates should be between 22 and 25 years old and must possess honours degree in natural science and aptitude for field observation. Experience of big game hunting desirable. Appointment pensionable in salary scale £688 to £1,680 per annum, plus expatriation allowance £182 to £364 per annum and cost of living allowance at present £221 to £497 per annum. Credit given for experience when determining initial salary. Free passages on appointment and leave for officer and family. Government quarters when available at moderate rental. Free medical attention. Generous home leave. Taxation at local rates.

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Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience, and mentioning this paper to the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting on letter M.28135.E. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

METALLURGIST REQUIRED BY MINISTRY of Supply as Scientific Officer at London Headquarters, to assist in research and development on metallic materials for aircraft construction; to progress research contracts with universities, research associations, materials manufacturers, and aircraft constructors. Qualifications, first- or second-class honours degree or equivalent in metallurgy. Research experience and some knowledge of light alloy technology and of fatigue of metals desirable. Salary within range, £440 to £707. Women somewhat less. Post unestablished. F.S.S.U. benefits may be available.—Application forms from Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.33/53A.

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THE RESEARCH DIVISION OF PEST CONtrol Limited, Cambridge, has two posts (one senior and one junior) to offer graduate organic chemists, to engage in fundamental synthetic work. The junior post carries an initial salary of £500 per annum, the senior post a salary according to ability and qualifications.—Applications (quoting Ad.775), should be addressed to the Personnel Manager, Pest Control Limited, Bourn, Cambridge, stating age, and fullest particulars, etc.

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Applications for grants from the first allotment of the Government Grant for Scientific Investigations for the year 1953, should be made as soon as possible on forms of application to be obtained from the Assistant Secretary of the Royal Society, Burlington House, London, W.1. No application can be considered which is received later than March 31, 1953.

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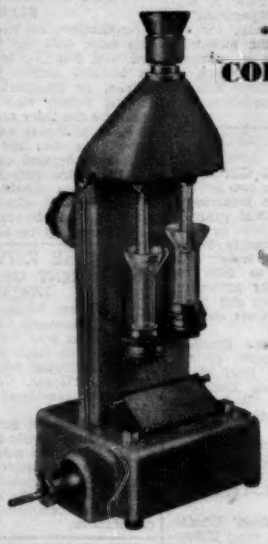

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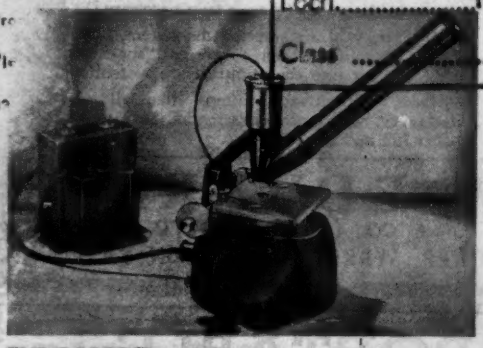

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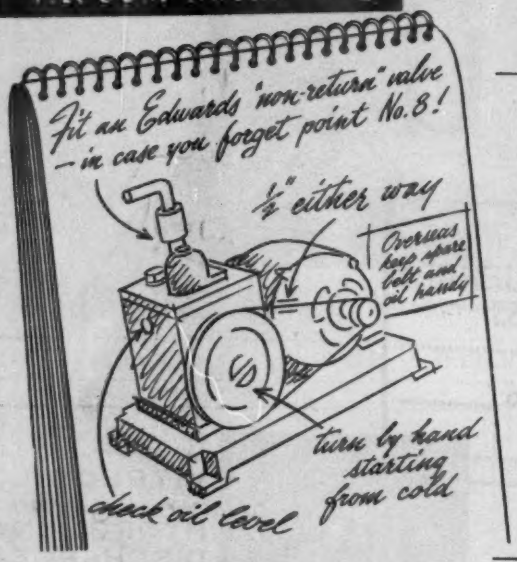
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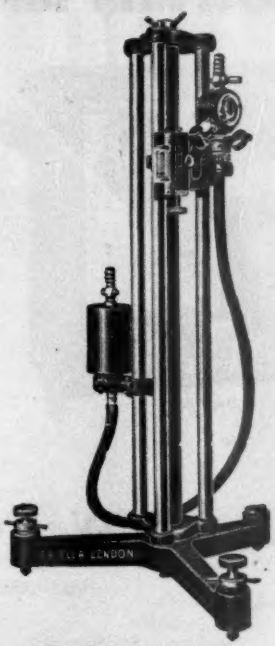

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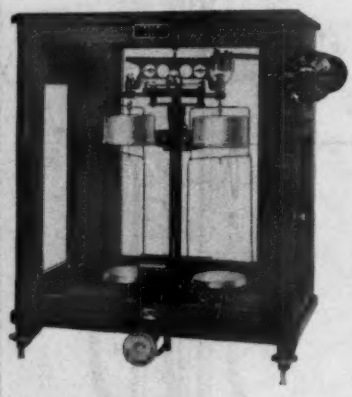

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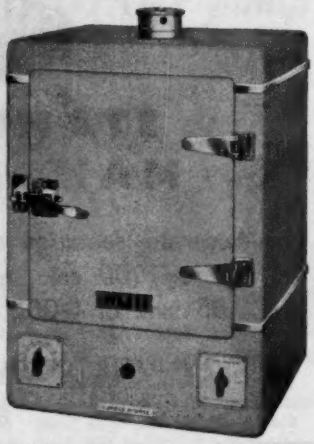

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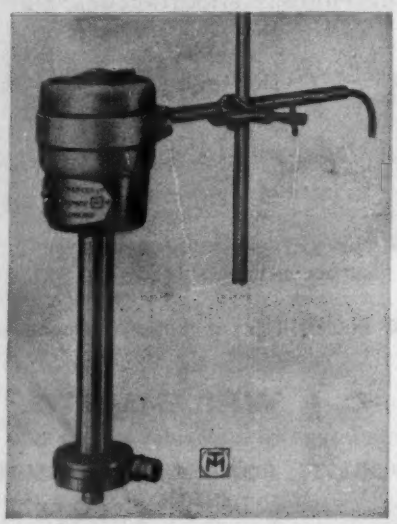

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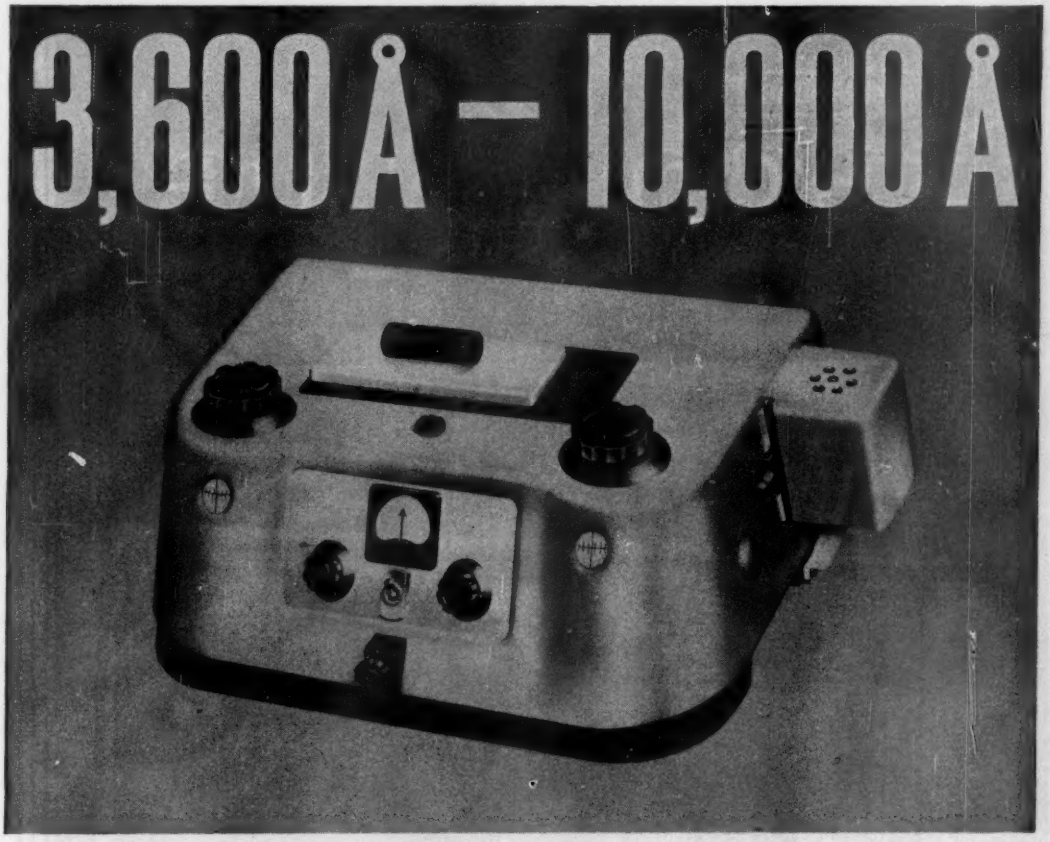

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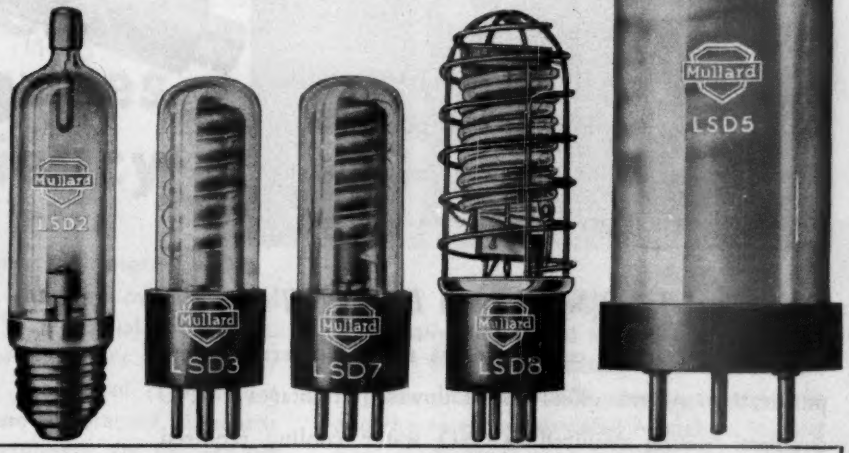

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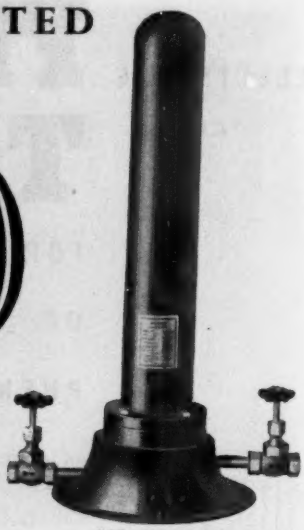

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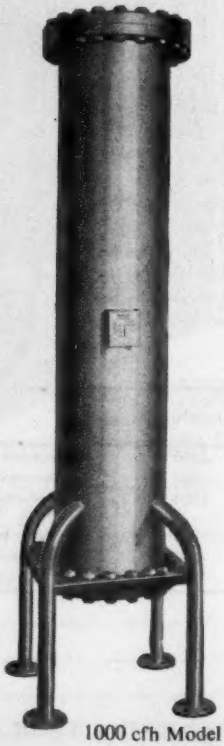

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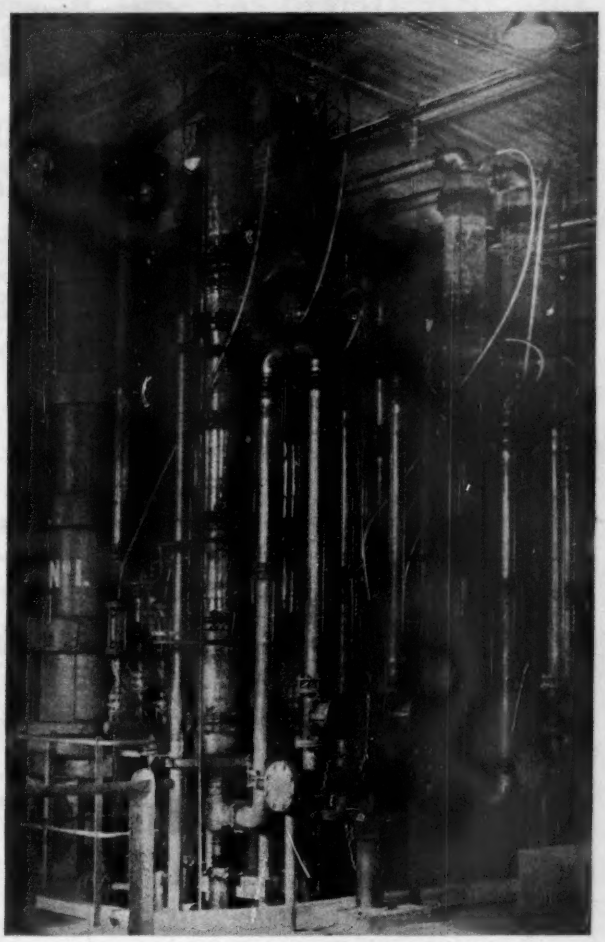

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NATURE

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OVERSEAS DEVELOPMENT AND MAN-POWER PROBLEMS

THE Volta River aluminium scheme set forth in a White Paper issued in November 1952 is of exceptional interest, quite apart from its possible contribution to the supply to the industry of the United Kingdom of aluminium from within the 'sterling area' at competitive prices. Under the scheme the United Kingdom Government, the Gold Coast Government and the producers would develop the resources of water-power and bauxite in the Gold Coast to yield ultimately 210,000 tons of aluminium annually. An initial capital expenditure of about £100 million would be required, rising eventually to £144 million, and in the White Paper the British Government states that it believes the scheme to be soundly conceived. The magnitude of the undertaking is such, however, that it considers that the scheme should not be embarked upon without every practicable assurance that it can be carried through to a successful conclusion. The British Government proposes, therefore, with the agreement of the Gold Coast Government and the aluminium producers, to set up at once a Preparatory Commission to follow up the work already done and to examine in greater detail the chief problems which would have to be overcome. This Commission would be instructed to report with all practicable speed so that final decisions could be taken as soon as possible. The cost of this Commission, of which Commander R. G. A. Jackson will be in charge (see *Nature*, February 21, p. 330), will be shared in the first place between the Governments of the United Kingdom and of the Gold Coast.

The wider interest of the scheme is derived, however, from its bearing on Colonial development and welfare. In commending the scheme, the White Paper points out that as one result the Gold Coast would be enabled to develop further its mineral wealth and to create a new source of power of great potential benefit to its future social and economic progress; and a reason given for favouring participation in the scheme by the British Government is that it would further the Government's policy of encouraging the development of the resources of the Commonwealth as well as contributing to the raw material needs of the United Kingdom. This applies particularly to the hydro-electric aspect of the scheme. The possibility of developing hydro-electric power from the Volta River, which is the principal river of the Gold Coast, with a total length of some 1,000 miles and a drainage area of about 150,000 square miles, of which roughly 40 per cent lies within Gold Coast territory, has been considered at various times during the past three decades. Proposals for the construction of a dam at Ajena in the Akwapim Hills for generating power for the production of aluminium were considered by the Gold Coast Government in 1924; but a detailed survey started in 1938 by Mr. Duncan Rose was interrupted by the Second World War. Six years later, West African Aluminium, Ltd., was formed with Mr. Rose as

* Volta River Aluminium Scheme. (Cmd. 8702.) Pp. ii+22. (London: H.M. Stationery Office, 1952.) 9d. net.

chairman to carry the scheme further, while in January 1951 a joint mission of Aluminium, Ltd., of Canada and the British Aluminium Co., after further detailed study, reported that the scheme prepared by West African Aluminium, Ltd., was a sound engineering proposition and could produce aluminium at an economic cost.

Meanwhile, the Gold Coast Government, which had long recognized the possibilities of the Volta River, but which also realized that the heavy capital expenditure required would not be justified unless there were adequate industrial outlets for the large quantities of power produced, decided that the development of the Volta River basin should be viewed as a whole and in relation to the total economy of the Gold Coast, rather than merely in relation to the most important immediately visible outlet for power. In October 1949 it engaged Sir William Halcrow and Partners to undertake a survey of all aspects of the Volta River development, including not only hydro-electric power but also irrigation and drainage of lands in or near the catchment of the river, navigation on the river, transport and port facilities. The British Government itself both encouraged the examination of the practicability of aluminium production in the area by the joint mission of Aluminium, Ltd., and the British Aluminium Co. already noted, and provided in the year ended March 31, 1950, £15,000 for a scheme made under the Colonial Development and Welfare Acts for a comprehensive survey of all aspects of the scheme to determine the potential value of the river. During 1951–52 a further £19,000 was provided for a scheme for an aerial survey of part of the Volta River basin in connexion with the projected hydro-electric scheme.

Sir William Halcrow and Partners submitted a preliminary report dated July 25, 1950, and in a final report on August 15, 1951, set out a scheme for the development of the Volta basin. So far as it related to aluminium production, this report was the basis for the subsequent exploratory discussions between representatives of the United Kingdom and Gold Coast Governments, of Aluminium, Ltd., and of the British Aluminium Co. in October and November 1951 and in May 1952 in London, and in June 1952 in Accra. The discussions considered the conditions under which the two Governments and the aluminium companies might jointly participate in a scheme for aluminium production in the Gold Coast, and the scheme proposed in the White Paper is the outcome of these discussions.

The scheme now proposed envisages the construction of a dam and power-station at Ajena in the gorge through the Akwapim Hills and would create a lake with an area of some 2,000 square miles. After allowing for other users in the Gold Coast, the power available from the hydro-electric installation would suffice for an aluminium smelter, operating on bauxite drawn from reserves within the Gold Coast, and sited at Kpong, twelve miles from the dam, to produce 210,000 tons of aluminium a year. The smelter and bauxite mines would be managed by private enterprise through a smelter company financed mainly by the aluminium companies with some support from the Gold Coast Government, though the scheme contemplates that up to half the capital required to expand the capacity of the smelter from its initial 80,000 to 120,000 tons a year may be provided by the United Kingdom Government.

The United Kingdom and Gold Coast Governments would be jointly responsible for financing the hydro-electric undertaking as a whole, the ultimate cost of which is estimated at £54 million. Apart from a minimum of £8 million contributed by the Gold Coast Government, which would be solely responsible for facilities for the distribution of power to other users besides the smelter, this would be borne by the United Kingdom Government, whose maximum expenditure is visualized at £56·8 million. The Gold Coast Government would be responsible for providing the £26 million required for port, rail, road facilities and other public works. Apart from that fraction of capital for the smelter provided later by private investors, the remainder of the £144 million for the whole scheme would be provided by the Gold Coast Government or the aluminium companies.

As already indicated, the scheme contemplates extensive public works. Establishment of an aluminium industry of this magnitude would necessitate construction of a new port conveniently situated to serve its needs. Accra has already reached the limit of its capacity and is unsuitable for further development as a port. Takoradi, the only major port in the Gold Coast, has recently been extended, but Sir William Halcrow and Partners recommended that a new port to serve both the general and the aluminium needs should be constructed at Tema, about twenty miles east of Accra. After obtaining a second opinion the Gold Coast Government has already decided to construct a new port at Tema, whether or not the whole scheme is undertaken, and preliminary work is in hand.

Besides this, a considerable development of communications would be required, particularly of railways, linking the new port at Tema with both Accra and Kpong and providing for movement of the bauxite by rail. Existing roads would need improvement and new roads would have to be built. It is proposed accordingly that the Gold Coast Government should set up a Volta River Authority, which would be responsible for co-ordinating all planning and construction work arising out of the Volta River scheme, including the building of the dam and power station, the aluminium smelter and alumina works, port and railway facilities, roads and townships. On completion of the construction work, the Volta Electricity Board would be set up to assume responsibility for the management of the power undertaking and also for the installation of additional generating units, transmissions and extension to the original works.

It is this aspect of the scheme which strikes the imagination. The analogy with the Tennessee Valley Authority is unmistakable, and from the caution with which both the Gold Coast Government and that of the United Kingdom are proceeding it is clear that in the minds of all concerned the development

and welfare of the people of the Gold Coast and not the exploitation of an important mineral resource are the dominant considerations. The appointment of a preparatory commission to examine in greater detail the chief problems which would have to be overcome shows that the lessons of earlier failures, such as the groundnuts scheme in East Africa and the poultry scheme in Gambia, have been learnt; and the Gold Coast Government, no doubt with the warning of Abadan in mind, is no less anxious to avoid even the appearance of an infringement of national independence.

If the scheme proves practicable and the technical problems can be surmounted, the financial proposals appear to be reasonable and flexible enough to accommodate political changes if they are made in good faith. To execute the scheme, moreover, demands not merely the supply of capital by Great Britain and a further drain on the country's limited supplies of technical experts, but also co-operation over a period of years between such experts and the peoples of the Gold Coast. Under the proposed Volta River Authority, the people of the Gold Coast should receive a training in responsible local administration which may itself materially smooth the path for the advance of the Gold Coast towards Dominion status. The very conditions essential for the technical execution of the scheme involve a spirit of co-operation and mutual understanding and a training in democratic methods calculated to engender the atmosphere and the goodwill which are the best safeguards against dangers from prejudice, misunderstanding and racial sentiment a generation or more hence.

The importance of this factor was stressed by Lord Rennell in a debate in the House of Lords on the Gold Coast last July, and it affects equally the Technical Assistance programme of the United Nations. Lord Rennell inquired specifically regarding the relationship between the new nationalist governments which are being set up and European capital and investors, on one hand, and their own European staff, on the other. It is unlikely, he pointed out, that either capital or technologists would be attracted to the Gold Coast from Britain and the United States for the Volta River scheme unless the sponsors of the scheme have confidence in the direction of constitutional development there. The Parliamentary Under-Secretary of State for the Colonies, the Earl of Munster, in replying to the debate, was able to supply evidence that Dr. K. Nkrumah and the Ministers of the young Gold Coast Government recognize the need both to maintain the goodwill of overseas investors and to retain the services of their European staff, and are dealing with some success with the difficulties caused by the anti-European feeling which brought them to power.

Nevertheless, as was emphasized in a recent broadsheet from Political and Economic Planning (see *Nature*, **170**, 679; 1952), the supply and quality of the technical experts remain the critical factors, and in this respect the Volta River scheme is no exception. Such questions as the numbers of technical experts required and the conditions of service to be offered to them are among the most important which the Preparatory Commission will have to consider. Failure to handle them in a way which will attract men of the requisite calibre would jeopardize the execution of the scheme no matter how excellent its technical merits. Moreover, although the situation in regard to scientific and technical man-power for such projects may be easier than in November 1949, when Dr. W. F. P. McLintock expressed the view before the Parliamentary and Scientific Committee that Great Britain's man-power resources in this field were already strained to the utmost (cf. *Nature*, **165**, 251; 1950), it must not be assumed that no special efforts will be required to find the necessary staff or that the effect on the man-power situation can be disregarded. So late as May 1952, Lord Reading expressed the view that our own man-power was still severely strained, and it would seem that a report from the sub-committee of Lord Hankey's Technical Personnel Committee which is dealing with overseas requirements is overdue.

The last report on "Colonial Research" and the survey "The Colonial Territories 1951–52" both indicated some improvement in the staff position in the Colonial Service. Apart from this, up to September 30, 1952, Great Britain had offered 65 technical experts against a total of 136 requested under the technical co-operation scheme of the Colombo Plan. It has also offered 416 of the 613 training places requested, as well as a further 300 places against which nominations have yet to be made by Colombo Plan countries. These requests are chiefly for India, Pakistan and Ceylon: the needs of Burma and Indonesia have as yet scarcely been charted.

Thus the need for technical help in southern Asia is likely to exceed supply for a long time to come. Even, therefore, if the strain on the world's scientific and technical man-power is diminished by the new method of technical assistance for backward countries adopted by the United Nations, under which collective advice is given by the developed countries, it may still be necessary for the execution of such schemes to contemplate the recruitment of experts not merely from Great Britain but also from elsewhere. The United Kingdom Government itself has suggested that, in view of the difficulty of finding suitable experts for specific projects, requests for the services of British consultant firms and technical consultants could be considered as part of the Colombo Plan. Such requests have already been received from India, Pakistan and Ceylon and are being negotiated.

However successful the fuller use of scientists or technologists as consultants may prove in meeting the situation, more also in the way of international co-operation may well be required. The Parliamentary and Scientific Committee when discussing the general problem had Anglo-American co-operation specially in mind; but there is also a considerable reservoir on the European continent which could be tapped. Switzerland, Denmark, Austria and Western Germany might well contribute appreciably to the numbers of engineers, scientists and medical men required for such schemes as the Volta River project under appropriate conditions, and there might be advan-

tages in recruiting overseas staff from different countries, provided the essential conditions were fulfilled.

Those conditions, upon which the successful execution of even the soundest development scheme depends, are not purely technical on either side. Good faith and goodwill, vision and understanding as well as technical and scientific competence are required of the expert. Good faith and goodwill and imagination must no less be shown by the responsible government of the territory concerned. On that government rests, further, the responsibility for establishing the conditions which will both attract the capital required for development and the men to carry it out. Above all, having attracted the experts of the necessary quality, it must provide the conditions of service which will enlist their loyalty in the imaginative service not merely of one territory or people but, through that people and territory, of mankind.

PHYSICS OF THE EARTH

The Earth

Its Origin, History and Physical Constitution. By Dr. Harold Jeffreys. Third edition. Pp. xiv+392+10 plates. (Cambridge: At the University Press, 1952.) 70s. net.

A COMPARISON between the third edition of Jeffreys's book, "The Earth", long awaited by geophysicists and geologists, and the second edition (1929) brings out the developments in geophysics in recent years. In some geophysical fields the ideas of twenty-five years ago have been confirmed and expanded; in others they have had to be abandoned and frequently replaced by a variety of hypotheses conflicting with each other. In this latter group belong the hypotheses on the origin of the solar system and the earth. The chapters previously devoted to these subjects have been omitted in the new edition, which begins with fundamental equations of elastic and non-elastic motions. Unfortunately, experimental research on creep and plastic flow is still in its early stages, whereas the theoretical treatment of such processes and of fracture in the earth is very complicated except with very special assumptions. A short discussion of rock types and minerals concludes the first chapter.

Chapter 2, the theory of elastic waves, forms the basis for Chapter 3, on observational seismology, which opens with a few remarks on seismographs (pp. 64–65). In the discussion of records of nearby earthquakes, Jeffreys is handicapped by the fact that the European material on which he relies to a great extent is inferior to that available in several other regions of major activity. Data from the latter show more 'disturbing features' than Jeffreys mentions and leave little doubt that our ideas concerning the outer layers of the earth, including the so-called granitic layer in the continents, are even less certain than indicated by him. This chapter also includes discussions of travel times, of body waves and of surface waves, with examples of their use in determining the structure of the earth. In the concluding pages (119–120) of Chapter 3 a few hypotheses on microseisms are mentioned with some details concerning the ideas of Deacon, Longuet-Higgins and Miche concerning the process in which energy is transmitted from ocean waves to the bottom. Chapters 1 to 3, seismology in a wide sense, cover the first third of the book.

In Chapter 4 the figure and density of the earth are discussed. Here, as in other parts of the book, much is based on Jeffreys's own research. Some of the always-changing hypotheses concerning the outer and inner core—iron or high-pressure form of olivine or other material—are treated. Chapter 5 includes a discussion of the gravity field of the earth and of isostasy. Chapter 6 begins with theoretical problems connected with static loads. Solutions for elastic and non-elastic conditions are considered, and gravity anomalies are discussed. Jeffreys concludes that stress differences of at least $1{\cdot}5 \times 10^9$ dynes/cm.^{2} exist within the outermost 50 km. of the earth and that differences of the order of 2×10^8 may exist between depths of 50 to 600 km. without producing fracture.

Chapter 7 contains details of the theory of variations of latitude and the bodily tides of the earth and a discussion of the associated constants, and the succeeding chapter is devoted to tidal friction of the earth and other planets with some remarks on the resonance theory of the origin of the moon. Thus Chapters 4–8 (pp. 121–248) mainly cover geodetic problems.

The last third of the book begins with methods used to determine the age of the earth (Chapter 9). "There is general consistency with an age in the neighbourhood of 2000–3000 million years." The question as to whether the earth started as a hot or cool body enters here, as well as the problem of the thermal history of the earth (Chapter 10, pp. 271–302). If the earth was originally liquid and cooling, the solution of the problem as to where solidification started depends on the relationship between melting-point gradient and adiabatic gradient. Jeffreys believes that the former exceeds the latter at all depths, and that the earth's shell solidified from the bottom upwards. During solidification materials separated; some details are discussed. The problem of the heat developed in radioactive processes leads to a more detailed discussion of the radioactivity of rocks at present and in the past, and its effect on the assumed cooling of the earth. In the mantle, the depth where the temperature approaches the melting point most closely is most likely at the bottom of the 'intermediate layer' in the continents. Recent findings of a relatively large heat flow in the bottom of the Pacific remain unexplained. Jeffreys discusses here once more the composition of the core in the light of recent ideas about atomic structure, as well as Bullen's hypothesis that in the deeper parts of the earth the bulk modulus is mainly a function of pressure.

Chapter 11 is devoted to the origin of the earth's surface features and to geotectonic hypotheses such as the contraction theory (which Jeffreys supports) and convection theories. Also included are remarks on changes in the earth's rotation, elastic instability, the origin of the continents and ocean basins, and on volcanism. In Chapter 12, Jeffreys discusses various phenomena such as after-shocks, movements of the earth's axis, continental drift, surface features of the moon and growth of continents. On pp. 357–371 he gives a mathematical background for some of the problems. The book concludes with some "Notes" on recent findings, and a subject index.

Unfortunately no geophysicist can now be familiar with the progress made in all fields of geophysics nor study in detail the whole literature. Thus, in this new edition little or no space is devoted to problems concerning the earth's magnetism and to the results of Benioff or of M. Ewing and his group. Some geophysicists, geologists or geochemists will find that the discussion of one of their special problems is not quite up to date. But there can be no doubt that a study of the new edition of this classical work is essential for all those who are interested in the development and structure of the earth or in the properties of its interior. B. GUTENBERG

TEXT-BOOK ON PLANT PROTECTION

Elements of Plant Protection

By Dr. Louis L. Pyenson. (Wiley Farm Series.) Pp. x+538. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 40*s*. net.

DR. L. L. PYENSON has produced a comprehensive elementary text-book of plant protection. All types of plant pests are dealt with—animals, both invertebrate and vertebrate, fungus and virus diseases, and weeds. In addition, there is a section dealing with equipment required for combating plant pests.

Throughout the book the author's aim has been to emphasize the general principles underlying all plant protection rather than to specify each and every control method. He has therefore divided the book into a number of sections, each dealing with a particular group of plant pests, and he has introduced each section by one or more chapters describing simply the biology of the group. These introductory chapters are perhaps unnecessarily elementary for the majority of students; but they do emphasize that there must be a sound knowledge of the biology of a given pest before a suitable method for its control can be selected. Unfortunately, some of the information they contain has been over-generalized to the point of inaccuracy; the description of the characteristics of the insect nervous system (p. 29) is an example. But the author's wide experience has enabled him to present a balanced account of plant protection and to assess all control methods strictly at their true value.

Many features of the book are excellent, especially the diagrams detailing the life-histories of a large number of plant pests and the tables setting out such diverse things as the diets of various birds, the purposes and limitations of various insecticides, pests and plant diseases associated with certain weeds, and the compatibility of common spray materials, to mention only a few.

The information on the control of insect pests is sound, and, as a result of the approach by way of general principles, biological control is given fair consideration. Control of fungus and virus diseases of plants and weed control are also well described, while the section on application equipment is excellent. Of course, a good deal of the more specialized information given applies only in the United States. Also, the colloquial names of the species mentioned in the text are American and often not current in Britain. The latter difficulty is not very serious, since the scientific name is nearly always quoted in addition to the colloquial one. Each chapter is followed by a list of questions, which are well chosen and stimulate a critical and reasoned approach to the subject. The somewhat condensed style of writing presumably results from including so much information in a book of such modest size. This conciseness, however, while making the book less readable, has not interfered with its lucidity. The book is well produced and the printing legible; but the pages present a somewhat untidy appearance due to the method of word-spacing used. P. E. BURT

WAVE MECHANICS FOR BEGINNERS

Elements of Wave Mechanics

By Prof. N. F. Mott. Pp. ix+156. (Cambridge: At the University Press, 1952.) 21*s*. net.

ALTHOUGH the principles of wave mechanics have been well established for almost a quarter of a century, there is, at present, no unanimity of view regarding the most satisfactory way of presenting the subject to the beginner. A glance at the introductory chapters of the numerous books on wave mechanics, or quantum mechanics, published in recent years shows the extent to which authors differ in their method of introducing the new principles. Some favour an axiomatic approach and base the theory on a few precisely stated postulates the justification of which is simply that they lead to a successful theory. Others prefer a more historical approach in which the Correspondence Principle of Bohr and the analogies with geometrical and wave optics are stressed.

In this new book, which is intended to replace the older "An Outline of Wave Mechanics", Prof. N. F. Mott presents the theory as a logical development from what are now well-established experimental data. He writes: "The theory will be based on a single experimental fact, the diffraction of electron beams". There are undeniable advantages in this approach to the subject, and it is no objection to the method that the theory was, in fact, well established before these particular experiments were made. With the skill of an experienced teacher, Prof. Mott leads the student on, from the wave equations of classical physics to the fundamental Schrödinger equation, with a minimum of discomfort and a considerable sense of continuity. The well-known stumbling blocks, such as the complex character of the wave function and the linearity in the time of the time-dependent Schrödinger equation, are met and most skilfully disposed of, and, by a series of well-chosen examples, the principal features of wave mechanics are brought to light.

For a book of this size a surprisingly large field of physics is covered. Apart from the more usual topics, such matters as the excitation of an atom by a passing proton or α-particle are dealt with; there is a section on the theory of solids, and another on molecular structure; a few words are devoted to the relativistic wave equation and the positron; and the essentials of the theory of α- and β-decay of nuclei are made clear. A feature of the book which will commend it to both students and teachers is the inclusion of a number of well-chosen exercises.

The author says in the preface that this book was written for students of experimental physics and to serve as an introduction to more advanced books for

those who intend to specialize in this subject, and to these categories of students it can be unreservedly recommended. If those who afterwards study the more advanced text-books should be surprised at the difficulties they encounter, that will be due, not to any lack of rigour in their introduction to the subject, but to the skill with which they have been led along the smoothest paths at the beginning of their journey.

H. Jones

SECOND BERKELEY SYMPOSIUM ON STATISTICS

Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability

Held at the Statistical Laboratory, Department of Mathematics, University of California, July 31–August 12, 1950. Edited by Jerzy Neyman. Pp. xi+666. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1951.) 11 dollars.

A COLLECTION of papers presented at an international conference is apt to be disappointing. The proceedings take so long to appear in volume form that an author with something new to say is apt to publish it elsewhere for fear of anticipation. It has also to be admitted that some contributors have nothing much to say but think that the occasion is too good to let pass without sharing the limelight. In consequence, the final records of a conference tend to become monuments of past endeavour, with the magnificent façade of a mausoleum and about as much vitality as its contents.

But there are exceptions, and the Second Berkeley Symposium is among them. There are papers in this collection which will long be consulted as major contributions to mathematical statistics. Prof. J. Neyman is to be congratulated on the standard maintained by the contributors. The First Symposium was good, but this is even better, and if Prof. Neyman can continue at this level the Berkeley Symposia will take a high place among the statistical literature of the world.

There are forty-six papers in the collection: thirteen on mathematical statistics, fourteen on probability, five on astronomy, two on biometry, three on econometrics, five on physics, two on traffic engineering and two on wave analysis. The contributors to the first symposium were all United States citizens, but this collection contains some very distinguished foreign names—Cramér, de Finetti, Paul Lévy, Lindblad and Kampé de Fériet. There is, alas, no member of the British Commonwealth among them, but perhaps Prof. Neyman will remove this serious drawback in the third symposium which he hopes to organize.

Of the group on mathematical statistics, Wald's paper on asymptotic minimax solutions of point-estimation problems and Hoeffding's on optimum non-parametric tests, though written in abstract style, are well worth the trouble of mastering, a remark one cannot always make of papers in this subject. Hotelling, writing on a generalization of the *T*-test, shows how a difficult subject can be made lucid and readable. Blackwell's paper on the "Comparison of Experiments", following work by Bohnenblust, Shapley and Sherman, will be of general interest. An experiment α is said to be more informative than an experiment β if, for every possible risk function, any risk attainable with β is also attainable with α. On this basis one can develop a kind of logic of experiment and set up criteria for the choice of methods leading to results which are by no means intuitively obvious.

The group of papers on probability are mainly written around the theme of dynamic probabilities: Paul Lévy on Wiener's random function, Kac on some connexions between probability theory and differential and integral equations, Feller on diffusion processes in genetics (a very readable little paper), several papers on random walks and ergodic theorems, and one by Doob on "Continuous Parameter Martingales"—a title which, rightly handled, could have added much to the gaiety of the proceedings.

I am not competent to express an opinion on the merits of the papers on astronomy and physics, but the papers by Lindblad on the dynamics of stellar systems, by Struve on stellar evolution considered statistically, and by Elizabeth Scott on the distribution of the elements of spectroscopic binaries, offer some interesting new statistical problems. The group on physics (Feynman on the concept of probability in quantum mechanics, Lewis on statistical questions in meson theory, and Lenzen on the philosophical problems of the statistical interpretation of quantum mechanics) indicate the advent of a useful *rapprochement* between statistics as generally studied and the specialized statistics of physical systems.

The two papers in the biometry section are somewhat misleadingly placed, for both raise questions of general interest. Cochran writes on improvement by means of selection, an important but neglected topic. Berkson, who is building up a reputation as the *enfant terrible* of the biometric world, shows by experiment and example that minimum chi-squared can be better than maximum likelihood in certain cases, a result which will make many of us think again about certain problems in statistical estimation.

In the econometrics section, Kuhn and Tucker write on non-linear programming, Marschak on "Why should Statisticians and Businessmen Maximize Moral Expectation?" (nobody claims that they do, but it is an interesting problem in decision-theory to ascertain why they should), and Arrow on classical welfare economics. Papers in the traffic engineering section on the distribution of vehicle speeds and travel times are significant contributions to congestion problems; and to conclude there are two interesting papers on the analysis of ocean waves by the correlogram. It is tragic to have to record that the author of the last paper in the book, H. R. Seiwell, like the author of the first, Abraham Wald, lost his life in an accident since the symposium was held.

A mere list of these papers indicates the enormous range of statistical methods at the present time. A glance through them will show what demands many of the subjects make on mathematical expertise, experimental skill and computational patience. A statistician is torn between pleasure at the extensive use made of his methods and regret at his inability to keep up with so many different developments. One of the most useful features of a collection like this—some of the papers being in the nature of reviews of current work—is that it enables one to see the main currents and to form a broad picture of what is going on. It only remains to say that the book is handsomely produced. The price may put it beyond the reach of the student, but all statistical libraries should possess it.

M. G. Kendall

INSTRUMENTATION OF NUCLEAR REACTORS

At a general meeting of the Institution of Electrical Engineers, held in the Institution's Lecture Theatre on January 8, a symposium of papers on the instrumentation of nuclear reactors was organized, at which about five hundred members and visitors attended, including guests from nuclear energy projects in France, Holland, Sweden, Norway and Italy. Colonel B. H. Leeson, president of the Institution, took the chair and introduced Sir John Cockcroft, whose lecture on "Nuclear Reactors and their Applications" provided a general background for the three specialized papers which followed.

Sir John began by describing the fission process, in which interaction between a neutron and a uranium atom may result in absorption of the former followed by fission of the latter, accompanied by the liberation of further neutrons and the release of energy. The probability of occurrence of this reaction depends upon which isotope of uranium is concerned, and upon the energy of the incident neutron. A system designed to enhance this probability is known as a nuclear reactor, and a classification into three main types is possible: these are known as fast, intermediate and thermal reactors, according to the energy-level at which it is intended that the incident neutron will cause fission. The critical state of a nuclear reactor occurs when, out of the neutrons released in an average fission, one survives all the processes leading to neutron waste, and initiates a further fission. If, however, more than one survives, a cumulatively increasing or divergent reaction results. If the number surviving is smaller than unity, the reaction diminishes until the fissions occur at a rate proportional to their rate of spontaneous occurrence in an isolated sample of uranium. The number of survivors thus defined is known as the reproduction factor, denoted by the symbol K; while the reactivity is denoted by $(\delta K) = K - 1$.

Fast-fission reactors require a predominating proportion of the uranium-235 isotope in their design, as the 238 isotope can absorb high-energy neutrons quite strongly without fission occurring. Thermal reactors overcome this difficulty by surrounding the uranium in which the fission occurs by a moderator, the function of which is to absorb the energy of the neutron in a series of scattering collisions. Neutrons of thermal energy (about a fortieth of an electron-volt) are only slightly absorbed by uranium-238. The size of such a reactor is quite large, the mass of 'natural' uranium in the Harwell British Experimental Pile known as BEPO being forty tons and the mass of moderator (graphite in this case) eight hundred tons; 'natural' uranium occurs in the proportions 140 parts of uranium-238 to 1 part of uranium-235. The critical size of a thermal neutron reactor may be reduced by artificially increasing the proportion of uranium-235 present in the uranium, and this sub-type of thermal reactor is known as an enriched reactor.

The third reactor-type employs a neutron energy for causing fission intermediate between fast and thermal, that is, some moderator is used. This is known as an intermediate reactor, and is likely to have importance for mobile nuclear power-plants.

The most important characteristic of a reactor is its neutron balance. A typical balance-sheet for a graphite-moderated thermal neutron reactor is as follows:

Neutrons produced in fission of uranium-235 and in fast fission	2·56
Neutrons carrying on the chain reaction	1
Neutrons absorbed in uranium-238 to produce plutonium-239	0·9
Neutrons absorbed in uranium-235 to produce uranium-236	0·2
Neutrons absorbed in moderator	0·3
Neutrons absorbed in structural materials	0·05
Neutrons escaping from core	0·09
Excess neutrons	0·02
	2·56

Temperatures and neutron-absorbing properties of fission residues affect this balance-sheet and adequate excess K must be allowed for. Since, however, steady-state operation means that $K = 1$, control rods have to be provided to absorb any excess of neutrons not required at any particular time.

The plutonium-239 mentioned on the balance sheet can be split by slow neutrons, so that this provides a means of utilizing some of the uranium-238 in addition to the uranium-235. An ideal reactor would produce more secondary fuel (that is, plutonium-239) than primary fuel burnt (that is, uranium-235). With such a 'breeder' reactor we could expect to burn up a great part of the uranium-238.

Having briefly surveyed the principles of nuclear reactor operation, Sir John Cockcroft then discussed some of the technical problems of reactors, under the four groupings of physical, metallurgical, chemical and engineering. The physicists are responsible for the calculations of critical size, supplemented and checked by 'exponential experiments' on a sub-critical reacting-core. They must also determine the adequacy of the means of control and the shielding required. Metallurgists are concerned with the preparation of the uranium fuel elements. Due to the peculiar lattice-structure of uranium, serious distortion may be caused by thermal cycling and exposure to radiation. The uranium is sheathed in a suitable metal to seal it completely, and this metal must resist radioactive irradiations, not absorb too many neutrons and withstand the temperatures required by the engineers. Chemical reactions may be accelerated under irradiation, and chemists are required to study corrosion effects between reactor materials. The engineers have to weave together all these components into a feasible design, including the heat-transfer arrangements, the provision of adequate cooling in all circumstances, control and safety.

Turning next to reactors for producing power, Sir John distinguished between the production of substantial quantities of economic power and the development of specialized power-units, for example, for ship propulsion. The first stage in achieving the former target might well be the construction of thermal neutron reactors using natural uranium as a fuel, and either heavy water or graphite as a moderator. Design studies of this type of plant indicate that sizeable blocks of power could be generated at 20–25 per cent efficiency and that, making the conservative assumption that the capital cost of the nuclear station would be twice that of its coal-fired counterpart, and taking realistic figures for the cost of uranium, the cost of the power generated would not be greatly different from conventional practice.

Sir John stressed that no credit is allowed in the above figures for the value of the residual plutonium. If, for example, of the uranium-235, one-third were consumed, or 2·3 kgm./ton, the reactor would have produced 1·5–2 kgm. of plutonium per ton. This would then be available as a basic fuel for the second stage of the power development programme, the breeder reactor stage.

The first approach to breeder reactors will be to develop fast-fission reactors for this purpose, taking advantage of the greatly reduced absorption of fast neutrons by the materials of construction in reactors, and probably using plutonium as the fuel because its average neutron release is nearer 3 than 2·55. An experimental power-producing fast reactor has been working for some time in the United States and made up of a core, "about the size of a regulation football", consisting of uranium with a very high proportion of uranium-235 canned in some suitable metal. The heat developed by the burning of the uranium-235 is removed by the circulation of liquid sodium–potassium alloy. The liquid metal passes through a heat exchanger, and steam is developed to drive a 250-kW. power unit. It has not been made public whether breeding has been achieved, although it is said to be "a promising youngster".

Sir John next reviewed the contribution of nuclear power to the resources of world energy, taking his figures (which are in 10^{18} B.Th.U.) mainly from the recent report of the Materials Policy Commission to the President of the United States: the present world annual output of energy is 0·2; the world reserves of coal are United States 7·6, Canada 2, United Kingdom 1, China 6, U.S.S.R. 10 and others 6, the whole totalling 33; and the total world reserves of oil are, proved 1 and unproved 4·6, totalling 5·6. The same report estimates that about 25 million tons of uranium are available if we are prepared to pay 100 dollars per lb. of uranium in the ore. If breeding and 100 per cent utilization of uranium were achieved, this would add $1{,}700 \times 10^{18}$ B.Th.U. to world reserves. If we were prepared to pay only 50 dollars/lb., the available reserves would be 250×10^{18} B.Th.U. Even at the higher figures, the primary fuel cost would be negligible if breeding were successful. This can be seen at once, since, on these assumptions, the needs of the United Kingdom can be met by 10–15 tons uranium a year at a primary fuel cost of less than 10 million dollars.

In conclusion, Sir John said that the time is not far off when nuclear power using natural uranium fuel will become feasible. These plants would work at reasonable efficiency and would produce power probably at a cost not very much more than from conventional power stations. This would seem to be sufficient to ask from the first experimental units, as all experience shows that costs may be expected to come down as experience accumulates.

Sir John Cockcroft was followed by Mr. R. V. Moore, who introduced his paper on "The Control of a Thermal Neutron Reactor". The operating characteristics of such a reactor were described, both on theoretical grounds and in the light of five years of operation of the Harwell reactors. The importance of the phenomenon of delayed neutrons on the controllability of the reactor was emphasized, and the following self-induced changes in the reactivity of the system were described: fuel depletion due to burning of uranium-235; poisoning due to the accumulation (owing to fission of uranium) of elements near the centre of the periodic table, certain of these elements (notably xenon-135) being powerful neutron-absorbers; and effects of temperature on reactivity.

The large thermal capacity inevitable with this type of reactor was mentioned, being illustrated by temperature–time curves for BEPO. The self-stabilizing phenomena of thermal reactors were described—that is, if the reactivity is increased for any reason so that the pile becomes divergent, by suitable design the reaction can be made to terminate itself. This is because the temperature coefficients are negative—namely, increased temperature involves a self-induced diminution of reactivity. Conditions at starting up and shutting down a reactor were described, as special safety considerations then apply. When starting up, there is an interval during which the neutron density is being raised from an infinitesimal level, which normally applies in the sub-critical state, to the lowest level that the installed instruments are capable of measuring. It is important that the reactor should arrive at this lowest detectable level still diverging sufficiently slowly to enable control to be established. If the reactor has been allowed to acquire excessive reactivity during this 'blind' period, the rate of divergence might be dangerous. On the other hand, advanced types of thermal reactor must be equipped with considerable potential reactivity to counteract the self-induced changes already mentioned. It was Mr. Moore's suggestion that this difficulty could be safely resolved by limiting the rate at which the reactivity might be increased. By studying the self-induced changes, a rate of withdrawal of the control rod may be determined which is normally adequate to compensate these, but which avoids the dangerous start-up condition. At shut-down the difficulty arises that the nuclear reaction cannot be completely cut off at will. This implies that adequate cooling to balance the residual heating must always be available.

The paper concluded by postulating various fault conditions and examining their consequences, and it was Mr. Moore's conclusion that a system of control for thermal nuclear reactors could be evolved which would be inherently safe.

Mr. J. H. Bowen then introduced his paper on "Automatic Control Characteristics of Thermal-Neutron Reactors". From an operating point of view, it is a convenience to abolish all consideration of the rather complex relation between the variation of reactivity and the subsequent variation of power, by installing an automatic power-controller. This device measures the instantaneous reactor power-level and adjusts the reactivity to bring the power automatically to some predetermined or desired level. The differential equations describing the operation of this device include terms involving the response of the reactor to variation of reactivity. These terms, described in the paper as the reactor "transfer function", have been obtained analytically and confirmed by experiment. Typical complete control-system responses have been calculated and checked by experiment, with good agreement, and a design method for reactor control-systems was suggested.

The final paper, "Neutron Detectors for Reactor Instrumentation", by T. A. J. Jaques, H. A. Ballinger and F. Wade, was introduced by Mr. Jaques. It discussed the principles involved in the detection of thermal neutrons and described two new types of detector recently developed in connexion with the operation of thermal reactors. The first is mainly used as a flux-scanning detector—that is, for local

measurements of flux density—and is essentially a thermopile with its hot and cold junctions placed adjacent to each other to share equal ambient temperature conditions. One set of junctions, however, is embedded in boron. Under neutron irradiation, the boron – neutron reaction causes unbalanced heating of the junctions, and the instrument thus develops a thermal E.M.F. proportional to the neutron flux density. The response time-constant is of the order of ten seconds.

The second new type is an ionization chamber. These chambers are normally slightly sensitive to incident gamma-ray radiation, in addition to the intended response to neutron flux. This effect has some importance when the reactor is operating at low power following conditions of high-power running, since the residual gamma-radiation may then be comparatively intense whereas the neutron flux is weak. The new chambers are intended partially to overcome this difficulty by measuring separately the gamma-radiation and the neutron-plus-gamma-radiation. The former measurement is then automatically subtracted from the latter to leave the quantity required.

In opening the discussion which followed these papers, Dr. Dennis Taylor suggested the use of pulse counters at start-up. These could best be used in conjunction with a logarithmic rate-meter, and the possibility then exists of obtaining directly a measure of the pile reactivity. A period-meter or reactivity-meter of this sort is under development at Harwell. When considering extending the range of power measurements, an inevitable question which arises is whether or not electrometer valves can be considered sufficiently reliable for important applications. In this connexion Dr. Taylor reported the experience gained on BEPO: in the past two years not a single failure due to electrometer valves has been recorded in the log-book.

Dr. A. Lundby (Norway) stated that, in the operation of a heavy-water thermal reactor, photo-emission of neutrons from deuterium by gamma-radiation has some important effects on reactor control. He believed that the gamma-radiation mainly responsible for this effect is due to the reaction Ba $\rightarrow$ ^{140}La which has a period of 12·8 days.

Mr. R. Westergaard (Sweden) suggested that Mr. Bowen's paper would be improved by the consideration of the effects of time delays at various points in the system. In particular, he had in mind the use of pulse counters or rate-meters for power measurements at low flux, as this provides an excellent method of discriminating against gamma-radiation. But the statistical fluctuations involved in such measurements can only be reduced by rather long integrating-times at the rate-meter, and this must involve corresponding time delays in the automatic-control loop.

Referring to Section 8 of Mr. Moore's paper, M. M. Surdin (France) said that it is the practice to start up the French reactors in the manner suggested, namely, by slowly withdrawing the control rods at constant speed. This speed has been chosen so that the maximum reactivity during the starting transient will not exceed the arbitrary value of 0·3 per cent. This speed corresponds to a rate of reactivity increase of 10^{-5} per sec. In this connexion he referred to a calculation by M. M. Ravievski which showed that, when starting up in this manner, the power at which the critical condition is reached depends only on the rate of reactivity increase. (It may be noted here that similar calculations by J. Woodrow, of Harwell, show that this power is also proportional to the spontaneous or starting power in the shut-down state.)

Mr. W. Kealy (Department of Atomic Energy) made the comment that a reactor entirely devoted to isotope production would be controlled to work continuously at maximum power. This would be limited by temperature considerations, and it is found in practice that fluctuations in the frequency of the electricity supply are sufficient to vary these temperatures by as much as 6 per cent. The system of automatic power control described in Mr. Bowen's paper has to be supplemented by a temperature-sensitive control which, in fact, adjusts the set point of the power controller.

Reference was made by Mr. L. C. Ludbrook (British Thomson-Houston Co., Ltd.) to a few experiments he has made in connexion with the design of a reactor-power controller. These lead to a reactor transfer function in close agreement with Mr. Bowen's, although the approach has been entirely different.

Mr. S. A. Ghalib (Metropolitan-Vickers Electrical Co., Ltd.) said that, in addition to the corrosion problems mentioned by Sir John Cockcroft, a further difficulty for engineers in reactor design work is the problem of friction and wear in these mechanisms, which have to function, often without lubrication and maintenance, in the gas chosen as the reactor coolant. Another point concerns the range of the level of reactor power, quoted in Mr. Moore's paper as 10^{14}. This obviously applies between the shut-down and full-power states, but Mr. Ghalib suggested that in normal power-producing operations a range of 20 to 1 would be more probable.

CYTOCHROME OXIDASE AND THE 'PASTEUR ENZYME'

By Prof. D. KEILIN, F.R.S., and Dr. E. F. HARTREE
Molteno Institute, University of Cambridge

IT was shown in 1925 that the multibanded absorption spectrum of cytochrome belongs to three hæmochromogen-like components, denoted as cytochromes *a*, *b* and *c*, the oxidation and reduction of which—that is, their catalytic activity in respiration—can easily be observed in living intact cells[1]. However, further spectroscopic studies[2] of the activity of a typical cytochrome system in heart muscle preparations or in suspensions of certain micro-organisms in the presence of different substrates and inhibitors revealed that the absorption bands, at about 605 mμ and 448 mμ (α- and γ-bands), do not belong solely to cytochrome *a* but represent the superimposed and fused bands of two cytochrome components *a* and a_3. Cytochrome a_3, unlike cytochromes *a*, *b* and *c*, is very autoxidizable and combines reversibly with respiratory inhibitors such as cyanide, azide, hydrosulphide and carbon monoxide. These properties of cytochrome a_3, together with the fact that the absorption bands of its carbon monoxide derivative (α 590 mμ, and γ 432 mμ) occupy approximately the same position as the α- and γ-bands in the photochemical absorption spectrum of yeast[3,4], enabled us[2] to identify it with cytochrome oxidase or Warburg's "respiratory ferment". Cytochromes *a*

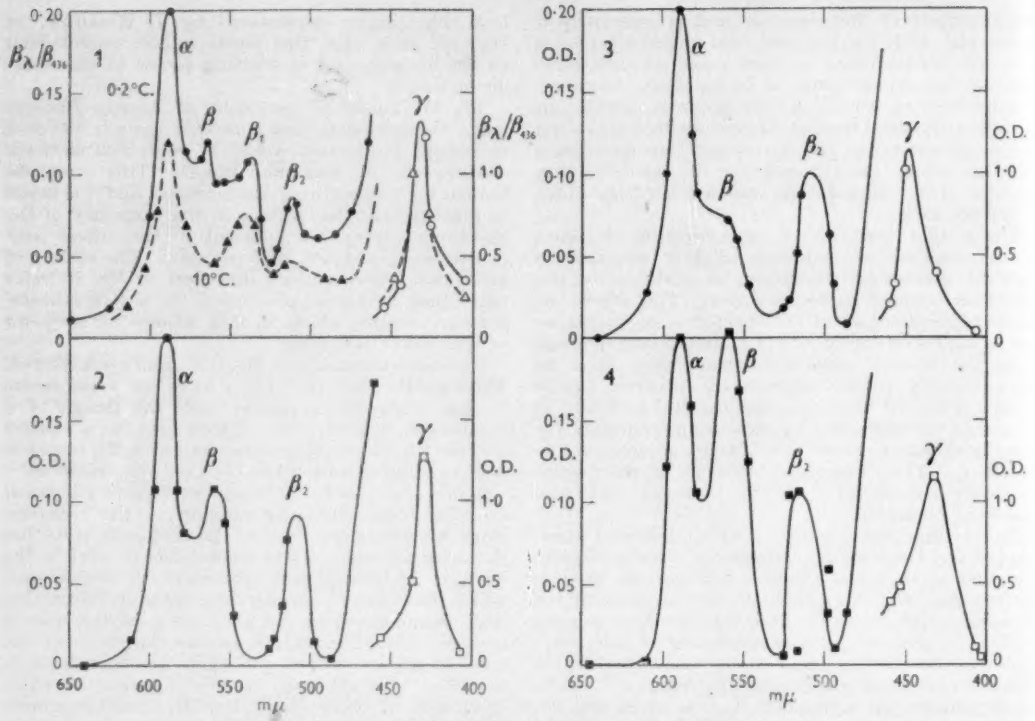

Fig. 1. Relative photochemical absorption spectra of *Torula utilis* at 0·2° and 10° C. from data of Kubowitz and Haas (ref. 4). Ordinate scale reduced ten-fold for Soret or γ-bands in Figs. 1–5

Fig. 2. Relative photochemical absorption spectrum of bakers' yeast replotted from data of Melnick (ref. 5) with ordinate scale adjusted as described in the text. O.D. = optical density

Figs. 3 and 4. Relative photochemical absorption spectra with adjusted ordinate scale: (3) heart muscle preparation + succinic acid from data of Melnick (ref. 6); (4) area vitellina of chick embryo from data of Philips (ref. 8)

and a_3 probably have identical chemical structures so far as both the hæm and protein are concerned. The difference in their reactivities may be due to differences in the mode of attachment of the hæm to the protein.

Since the introduction of a photochemical method[3] for the study of the absorption spectrum of the carbon monoxide derivative of the 'respiratory ferment', photochemical absorption spectra have been obtained for *Torula utilis* and *Acetobacter pasteurianum* by Warburg and Negelein[3] and by Kubowitz and Haas[4], for bakers' yeast and a colloidal heart muscle preparation by Melnick[5,6], and for the area vitellina of the chick embryo by Philips[7,8]. To this list can be added two photochemical absorption spectra ascribed to the 'Pasteur enzyme': one obtained for rat retina by Stern and Melnick[9], and the other for bakers' yeast by Melnick[6].

The very limited use that has so far been made of the photochemical method since its introduction more than twenty years ago[3] is not due solely to its elaborate and specialized technique but also to certain restrictions in the type of material which can be studied by this method. In fact, the respiration of cells and tissues, even when it depends upon the cytochrome system, is not always inhibited by carbon monoxide, and, when a marked inhibition by carbon monoxide is obtained, it is by no means invariably reversed by light. Moreover, in micro-organisms the components of cytochrome, including cytochrome oxidase, may show marked variations in absorption spectra and other properties.

Comparative Study of Photochemical Absorption Spectra

Of the photochemical absorption spectra so far recorded, those obtained by Kubowitz and Haas[4] are of special interest since they are based upon determinations at thirty different wave-lengths ranging from 253 to 671 mμ.

In order to compare the absorption spectra enumerated above and to bring into evidence the characteristics they have in common, they have been replotted (Figs. 1–5) in the following manner. The height of the α-band was taken as a point of reference, and the optical densities were recalculated to give equal densities of 0·20 at the peak of the α-band. This figure is the value for β_{552}/β_{436} obtained by Kubowitz and Haas[4] in their determination of the photochemical absorption of *T. utilis* at 0·2°. Examination of these absorption spectra reveals marked variations in the number, shape, positions and the relative heights of the bands. Among the most striking features of these spectra are the following: the great complexity of the absorption spectrum in the visible region of *T. utilis* recorded by Kubowitz and Haas[4] at 0·2° C. (Fig. 1); the prominence of β_2 bands in the remaining spectra, including those ascribed to the 'Pasteur enzyme'; the obliteration of the β-band in the heart muscle preparation (Fig. 3); the unusually high β-band in the case of the chick embryo (Fig. 4) where this band is, if anything, higher than the α-band and where the trough between α- and β-bands is unusually deep for

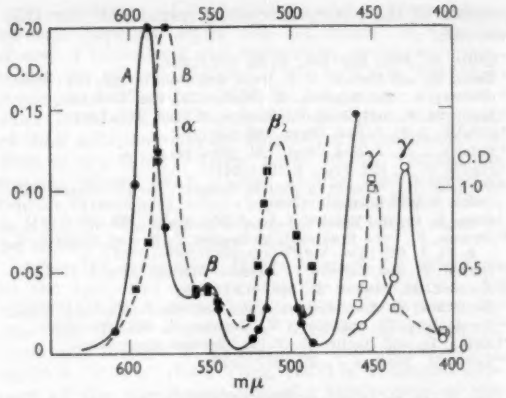

Fig. 5. Relative photochemical absorption spectra of the 'Pasteur enzyme' with adjusted ordinate scale: (*A*) bakers' yeast from data of Melnick (ref. 5); (*B*) retina of rat from data of Stern and Melnick (ref. 9)

the carbon monoxide derivative of a hæmoprotein; the position of the γ-band in the photochemical absorption spectrum of the heart muscle preparation which is at about 450 mμ, whereas direct spectroscopic study of this preparation revealed that on treatment with carbon monoxide the γ-band of cytochrome a_3 moves from 445 to about 432 mμ [8].

The differences between the photochemical absorption spectra of the 'Pasteur enzymes' (Fig. 5) in bakers' yeast (*A*) and retina (*B*) are much more marked than the differences between either of them and some of the photochemical spectra of the 'respiratory ferment'. In fact, the spectra of the 'Pasteur enzyme' and of the 'respiratory ferment' in bakers' yeast (Figs. 5 and 2), as determined by Melnick[5], are virtually identical except that the β-band is much lower in the 'Pasteur enzyme' spectrum, where it is more comparable with the β-band of the 'respiratory ferment' in the heart muscle preparation (Fig. 3). On the other hand, the γ-band of the latter and of the 'Pasteur enzyme' of the retina (Fig. 5,*B*) were recorded at 450 mμ, which is 18–20 mμ nearer the red end of the spectrum than the corresponding bands in all the other photochemical absorption spectra. Thus, an analysis of the photochemical absorption spectra does not support the view that the 'Pasteur enzyme' and cytochrome oxidase are two distinct enzymes. Similar doubts as to the distinction between the two enzymes have already been expressed by Dickens[10].

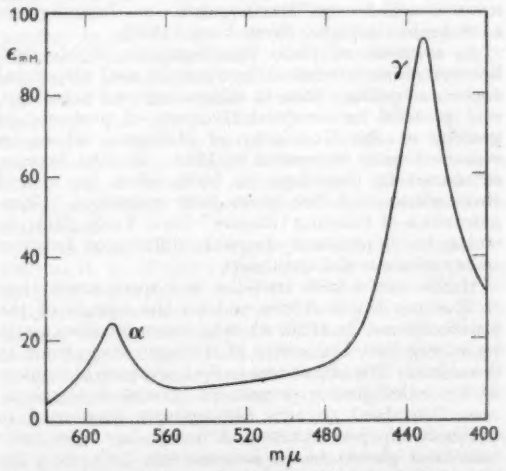

Fig. 6. Absorption spectrum of pyridine hæmochromogen obtained from hæmatin of cytochrome *a* (after Rawlinson and Hale (ref. 13))

Interpretation of the Photochemical Absorption Spectra

The foregoing discussion of the photochemical absorption spectra suggests the following possible explanations of their great complexity and variability.

(*a*) The lack of agreement between the curves may be due to experimental errors inherent in the method and to great technical difficulties in its application. This is partly supported by marked differences in the spectra recorded for *T. utilis*[4] at 0·2° and 10° C. (Fig. 1).

(*b*) It is, on the other hand, possible that the differences in the spectra are genuine and that they reflect differences in the structure of the cytochrome oxidase of different cells, such as would be expected to arise from variations of the protein portion of its molecule. However, this would scarcely explain the marked differences in the spectra obtained for *T. utilis* and bakers' yeast, or for the heart muscle preparation and the chick embryo.

(*c*) Finally, one cannot exclude the possibility that, although in the main the photochemical absorption spectrum represents the carbon monoxide compound of cytochrome oxidase, the complexity and variability of the spectrum may reflect the influence upon it of light absorption by other intracellular components, and in particular by the cytochromes that are intimately linked with the oxidase. This hypothesis is supported by the presence of the protein band in the photochemical absorption spectra of *T. utilis* and *A. pasteurianum* recorded by Warburg and Negelein[2], by Kubowitz and Haas[4] and by the recent finding by Bücher and Kaspers[11] of the protein band in the photodissociation spectrum of carbon monoxide myoglobin. In all these cases the light energy absorbed by tyrosine and tryptophane residues of the protein at about 280 mμ is transmitted to the hæm and utilized for photodissociation of the iron – carbon monoxide link in the same way as light energy absorbed directly by the hæm nucleus.

Considering that all components of the cytochrome system are intimately linked together through their proteins, which probably provide suitable pathways for electron transfer from the iron of one to that of another component, it is conceivable that some of the light energy absorbed by components which react neither with oxygen nor with carbon monoxide may nevertheless be transmitted to carbon monoxide–cytochrome oxidase compounds of *Torula* and *Acetobacter* and be involved in their photodissociation in the same manner as light energy absorbed by tyrosine and tryptophane of the protein. Such a possibility may help us to understand the remarkable difference between the complex photochemical spectra and the simple one-banded absorption spectrum in the visible region of the pyridine hæmochromogen obtained from hæm *a* and a_3 by Negelein[12], by Rawlinson and Hale[13] (Fig. 6), and by Dannenberg and Kiese[14]. We have found, in addition, that the globin hæmochromogen of hæm $a + a_3$ shows the same single band at about 587 mμ which, in presence of carbon monoxide, shifts slightly towards the red end of the spectrum[15].

The foregoing view of the nature of the photochemical absorption spectra allows a simpler interpretation of their variability, since the relative proportions of the cytochrome components vary from one kind of cell to another[1]. The contribution to the photodissociation of the cytochrome oxidase – carbon monoxide compound by other components of the cytochrome system and possibly by some other light-absorbing substances would, in these circumstances, be a variable one. On the other hand, if more than one hæmoprotein contributes to the photochemical spectrum in the Soret region, the experimental γ-band should be somewhat asymmetric with shoulders representing the smaller contributions of components other than cytochrome oxidase. Unfortunately, sufficient data to decide this matter are not available, nor could they be easily obtained, since many experimental points would be required within a very limited spectral region to provide the exact shape of the γ-band.

However, the problem whether the carbon monoxide compound of cytochrome oxidase does exhibit a multibanded spectrum in the visible region, as the photochemical spectra appear to suggest, will be finally solved either by study of the isolated and purified native cytochrome a and a_3 hæmoproteins completely free from other native or denatured hæmoproteins, or by the study of absorption spectra of carbon monoxide complexes of compounds reconstructed from hæm a and different proteins. Until this is accomplished, the most plausible explanation of the great complexity and variations of the photochemical absorption spectra lies in the assumption that several light-absorbing components of the catalytic system contribute to the pattern of these spectra.

Since all the components of the cytochrome system are intimately linked together to form an integral part of certain structural elements of the cell such as mitochondria or sarcosomes, it is conceivable that the spatial distribution of cytochrome oxidase in relation to the other cytochrome components and other oxido-reduction systems varies from one structural element to another, or from one region of the same element to another. According to its localization, cytochrome oxidase may be linked in different manners and in different proportions to other components of catalytic systems and therefore may not be equally saturated in each case with electron donors. It is only in places where cytochrome oxidase is fully saturated with electron donors that its activity can become the rate-determining step and that its susceptibility to carbon monoxide will be reflected in the over-all reaction in which it takes part. This may explain the differences in the susceptibility to carbon monoxide of respiration and the Pasteur reaction discovered by Laser[16]. Thus his important observation that in certain tissues it is not the respiration but the Pasteur reaction that shows light-sensitive inhibition by carbon monoxide does not necessarily imply the existence of a specific 'Pasteur enzyme' which is distinct from cytochrome oxidase.

It is therefore reasonable to assume that cytochrome oxidase is the component, showing the light-sensitive inhibition by carbon monoxide and the photochemical absorption spectrum, of the catalytic system involved in the Pasteur reaction. As to the susceptibility of this reaction to other factors[16], which do not affect cytochrome oxidase, it may well be due to their action upon some other components of the catalytic system responsible for this reaction.

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OBITUARIES

Prof. W. H. Hobbs

William Herbert Hobbs was born at Worcester, Massachusetts, on July 2, 1864, and died at Ann Arbor, Michigan, early in January 1953. He was educated at the Worcester Polytechnic Institute, where he made a special study of industrial design. Upon graduation in June 1883 he taught for a year at a country school, and then went to Johns Hopkins University at Baltimore to study first chemistry and physics and later geology, in which he took his degree in 1888. After a year's postgraduate work at Heidelberg, Hobbs returned to the United States as an instructor in the University of Wisconsin and curator of the geological museum there. In 1891 he was appointed assistant professor of mineralogy and petrology, and nine years later became full professor. Between 1885 and 1900 he was also employed from time to time by the United States Geological Survey in New England, and made a special study of methods of discovering faults by means of surface relief. Hobbs was in Italy at the time of the Calabrian earthquake in 1905 and formed the opinion that there was no epicentrum, or centre of heavy shock, but many intersecting 'seismotectonic' lines of shock with the heaviest shocks at their junctions. He published this novel conclusion in "Earthquakes: an Introduction to Seismic Geology" (New York, 1907).

As a result of these investigations, Hobbs had become more interested in dynamic and structural aspects of geology than in mineralogy and petrology, and in 1906 he accepted the post of professor of geology at the University of Michigan, where he remained until retirement in 1934. He first became interested in glaciology in 1906, when he visited Switzerland, and five years later published "Characteristics of Existing Glaciers" (New York, 1911), in which he emphasized the wide differences between valley glaciers and ice sheets.

Hobbs was a keen traveller and spent much time in Europe, North Africa and on the islands of the Pacific Ocean. In 1926, when he was more than sixty, he led the first University of Michigan Expedition to Greenland. His object was to find evidence in support of his belief that a permanent 'glacial anticyclone' over Greenland governs atmospheric circulation in the northern hemisphere. Although his hypothesis was later shown to be inconsistent both with the observed facts and the theory of the polar front, Hobbs continued to assert that the character-

istic circulation of the northern and southern hemispheres depends upon the existence of the ice sheets of Greenland and Antarctica, acting as downshafts for the restoration of air to lower latitudes. Again, in 1927 and in 1928, he led parties to south-west Greenland, and later published a general account of their achievements in "Exploring about the North Pole of the Winds" (New York, 1930). During the Second World War it was Hobbs who suggested Søndre Strømfjord, where his expeditions had worked, as a site for the United States air base which came to be known as Bluie West Eight.

After his retirement Hobbs turned his attention to the historical aspects of polar exploration. As might be expected, he had entered whole-heartedly into the bitter controversy between Frederick A. Cook and Robery E. Peary, and wrote a biography entitled "Peary" (New York, 1936) in vehement support of the American admiral's attainment of the North Pole. Hobbs also devoted much attention to the discovery of the antarctic continent, and published the results of his investigations in 1937. In exceptionally harsh and acrid terms he sought to show that it was an American sealer, Nathaniel Brown Palmer, who first sighted Antarctica, although there is no doubt whatever that Edward Bransfield was, in fact, the first to do so. Hobbs's attempt to discredit men like Bransfield and James Weddell, and his ruthless misrepresentation of original documents, was a source of great embarrassment to his many friends in Britain.

Whatever doubt there may be as to the worth of Hobbs's contribution in some fields, of his vigour and enthusiasm there can be no question. He was never afraid to state his views, however controversial; but it is regrettable that he was so rarely prepared to admit, in the face of overwhelming evidence, that he had been mistaken. J. D. M. BLYTH

Prof. David Katz

THE death of Prof. David Katz on February 2 at the age of sixty-nine removes from psychology a gifted and versatile experimentalist of the first rank. Born in Cassel, Hessen-Nassau, in 1884, he studied natural science and mathematics at Göttingen and later turned to psychology, under the direction of G. E. Müller. It was characteristic of him that his interest in psychology was aroused by acting as a subject in an experiment. He pursued these early studies at Munich and Berlin, and it was during this time that he came under Husserl's influence, which remained throughout his life. On receiving his doctorate in 1906, he spent some months in military service and then proceeded to Munich, where Theodore Lipps was a focus of interest, and afterwards to Würzburg, where Kulpe's laboratory was the main attraction.

He took up his first appointment at Göttingen in 1907 as G. E. Müller's assistant, and remained there until the outbreak of the First World War, when he enlisted and served for nearly four years. In 1918 he had the opportunity of working for some time at the Engineering School in Hanover, being engaged in the study of sensory-motor reactions of Sauerbruch amputees, thus introducing psychological methods into the field of prosthesis.

In 1919 he married Rosa Heine, a psychologist in her own right, who has always been closely associated with her husband's work, particularly on child and animal behaviour.

In the same year Katz accepted the new chair of psychology and education at the University of Rostock. He stayed there until 1933 when he was forced to leave because of the Nazi regime. Fortunately, an invitation was extended to him to work in Prof. T. H. Pear's laboratory in the University of Manchester and later in Sir Cyril Burt's Department at University College, London. While in England he also carried out experiments on monkeys at the London Zoo and for two years acted as psychological adviser to the British Research Association of Flour Millers. In 1937, he was appointed to the first chair of pedagogy and psychology in the University of Stockholm, where he remained until his retirement in 1951.

The wide scope of Katz's experimental interests is indicated by his original work on sense perception (especially colour-vision, touch, taste and vibration), child development, processes of thought and learning, and animal behaviour. He preserved until the end an originality and freshness of approach in all his varied work, and his writings are characterized by simplicity, directness and lucidity.

During 1930–33 he was co-editor of the *Zeitschrift für Psychologie*. In 1950, he went to the University of California to deliver the Hitchcock Lectures, and in 1951 he was president of the Thirteenth International Congress of Psychology. His numerous publications include "Psychologie und Mathematische Unterricht", "Studien zur Kinderpsychologie", "The World of Colour", "The World of Touch", "Hunger and Appetite", "Conversations with Children" (jointly with Rosa Katz), "A Psychological Atlas", "Gestalt Psychology", and "Animals and Men".

Prof. Katz possessed great charm of personality and a sense of humour, and his unfailing kindness won him numerous friends in many countries. He leaves a widow and two sons. JOHN COHEN

Dr. Edward Hope

DR. EDWARD HOPE, who died at Caterham on February 7, was born on December 19, 1886, and received his chemical training under W. H. Perkin, jun., at the University of Manchester. His earliest researches included studies in the preparation and reactions of several interesting alicyclic and aliphatic acids, as well as some notable investigations, conducted in collaboration with Sir Robert Robinson, in the narcotine and gnoscopine group of alkaloids.

Perkin had moved to Oxford in 1913, and, during the First World War, British Dyes, Ltd., organized a team of chemists to investigate, under his direction, difficulties which had arisen in the manufacture of dyes and their intermediates. Hope went to Oxford in 1916 to join this team and worked in the newly opened Dyson Perrins Laboratory. In 1919 he accepted an appointment as lecturer and demonstrator in the new laboratory, and at the same time became a Fellow and tutor in chemistry at Magdalen College.

The immediate post-war period was one of considerable reorganization and development in the chemistry school at Oxford. The research year had just been introduced as an integral part of the honours course, and Hope applied himself wholeheartedly to the problems of the laboratory and the needs of a large body of pupils at Magdalen. He maintained his interest in research and published a number of papers jointly with his students, mostly on the

chemistry of substances related to the indigo dyes; but he was carrying a heavy burden of work and showed early signs of the ill-health which marked his later years. Although he found it necessary to relinquish his teaching duties at Magdalen in 1933, he remained at the College, where he filled various offices and ultimately became Senior Fellow. He continued his work at the Dyson Perrins Laboratory as a University demonstrator and lecturer until he reached the normal age of retirement in September of last year. For many years he edited the "Chemists' Year Book".

Hope will long be remembered with affection by his pupils and colleagues. He was a popular and successful tutor, and countless numbers of Oxford chemists will recall with gratitude the friendly advice and encouragement which they received from him in the laboratory. S. G. P. Plant

NEWS and VIEWS

Organic Chemistry in the University of Leeds: Prof. F. Challenger

Prof. F. Challenger, who retires from the chair of organic chemistry in the University of Leeds at the end of the present session, studied under Jamieson Walker, Kipping and Wallach, and held appointments in the Universities of Birmingham and Manchester before succeeding Ingold at Leeds in 1930 (see *Nature*, **126**, 187; 1930). He has seen the department move from its old outgrown quarters to the present large building, opened in 1933, and has seen that in turn strained to the utmost to contain the greatly increased numbers of post-war students. However, university expansion with its concomitant administrative problems has not kept Challenger away from the laboratory bench, nor has he shared the post-war doubts of some about the aims of a university; whether in the Senate, in the chair at the Ph.D. Committee, or in discussion with individual students, his influence has always been emphatically on the side of the pursuit of new knowledge. Challenger's friendly and generous disposition has not only established good relations between the Chemistry Department in Leeds and those elsewhere (particularly the Dutch schools of organic chemistry), but has also shown itself in the way he has helped a succession of postgraduate students who have worked with him, and in his unfailing courtesy and kindness to his colleagues.

Challenger's researches have been concerned principally with biological methylation and with the synthesis, structure and properties of heterocyclic sulphur compounds, particularly the thiophthens, the solid isomer of which he was the first to isolate. His studies of the methylating properties of moulds have revealed many interesting reactions, such as the fission and methylation of organic disulphides, the production of alkyl mercaptans from methionine and alkyl cysteines, as well as the methylation of inorganic and organic compounds of arsenic, selenium and tellurium. The last-named reaction is analogous to that which takes place in animals. His views on the similarity of the transmethylation mechanism in moulds and in animals have recently been confirmed by his own elegant experiments with compounds labelled with carbon-14. With Dr. Simpson he showed that the dimethyl sulphide evolved by the marine red alga *Polysiphonia fastigiata* arises from the decomposition of the thetine $(CH_3)_2\overset{+}{S}.CH_2.CH_2\,COO^-$; this compound, the first of its class to be found in plants, was shown later by du Vigneaud and by Dubnoff to act as a methyl donor in the conversion of homocysteine to methionine in rats, and a valuable link was thus forged between the parallel investigations in Leeds and Cornell. He has also demonstrated the presence of dimethyl sulphide (shown by Haas to occur in *Polysiphonia*) in numerous other plants.

Dr. B. Lythgoe

Dr. B. Lythgoe, who succeeds Prof. Challenger, is a Lancashire man. He was educated at Leigh Grammar School and the University of Manchester, where he graduated in 1934, and commenced postgraduate work in organic chemistry under the leadership of Sir Ian Heilbron. In this early phase of his career he was introduced to the chemistry of natural products and made important contributions to the study of algal carotenoids, including the isolation of myxoxanthin, the characteristic pigment of the Myxophyceæ. After a brief spell in industry, Dr. Lythgoe joined the staff of the Chemistry Department at Manchester in 1938, and there he began an association with Prof. A. R. Todd which, starting with some vitamin studies on the liver filtrate factor (pantothenic acid), developed into a co-operative attack on the problem of nucleoside structure. In a series of well-known investigations, spread over a number of years, the structure of the natural ribonucleosides was completely elucidated and their synthesis effected. It was during the development of this field that Dr. Lythgoe moved in 1944 with Prof. Todd to Cambridge, where he is at present lecturer in chemistry and a Fellow of King's College.

Parallel with the development of the work on nucleosides in Cambridge, Dr. Lythgoe's wide ranging interest in natural products caused him to initiate a series of brilliant researches on some unusual natural toxic principles, including the remarkable substance macrozamin, obtained from members of the Cycadaceæ, which he showed to be a derivative of azoxymethane, and the acetylenic substances responsible for the toxic effects of the British plants *Oenanthe crocata* and *Cicuta virosa*. These investigations and his other related studies have attracted much attention, both for their elegance in experimentation and for the theoretical insight which they display. Indeed Lythgoe's unusual combination of theoretical and natural product interests, coupled with his strong personality, assure a vigorous future for organic chemistry in Leeds.

Royal Society of Edinburgh: New Fellows

At the sixth ordinary meeting of the Royal Society of Edinburgh held in the Society's Rooms, 24 George Street, Edinburgh 2, on March 2, the following were elected Fellows of the Royal Society of Edinburgh: Prof. F. Bell, Department of Chemistry, Heriot-Watt College, Edinburgh; Mr. L. J. F. Brimble, joint-editor of *Nature*; Prof. J. L. Burchnall, Department of Pure Mathematics, University of Durham; Dr. E. A. C. Chamberlain, divisional chief scientist, Scottish Division, National

Coal Board; Prof. C. G. C. Chesters, Department of Botany, University of Nottingham; Dr. A. Clow, British Broadcasting Corporation; The Right Hon. the Earl of Crawford and Balcarres; Mr. A. A. Fulton, chief hydraulic engineer, North of Scotland Hydro-Electric Board; the Right Hon. the Earl of Haddington; Dr. J. Heslop Harrison, lecturer in the principles of plant taxonomy, University of London; the Right Hon. the Earl of Home, P.C., Minister of State, Scottish Office; Dr. D. B. McIntyre, lecturer in petrology, University of Edinburgh; Mr. B. G. McLellan, formerly director of the Scottish Seaweed Research Association; Sir James Irvine Masson, formerly vice-chancellor of the University of Sheffield; Dr. A. D. Merriman, registrar-secretary of the Institution of Metallurgists, London; Dr. A. R. Mitchell, lecturer in applied mathematics, University of St. Andrews; Dr. A. T. Phillipson, deputy director and head of the Physiology Department, Rowett Research Institute, Bucksburn, Aberdeenshire; Mr. K. S. M. Rae, officer-in-charge, Oceanographic Laboratory, Edinburgh; Dr. Edith P. Smith, lecturer in botany, University College, Dundee; Dr. J. T. Stamp, head of the Veterinary Department and veterinary investigation officer, Edinburgh and East of Scotland College of Agriculture; Dr. D. M. Steven, lecturer in zoology, University of Edinburgh; Prof. M. M. Swann, Department of Natural History, University of Edinburgh; Principal T. M. Taylor, vice-chancellor of the University of Aberdeen; Prof. W. L. Weipers, Department of Veterinary Surgery, University of Glasgow; Dr. L. H. Wells, senior lecturer in physical anthropology, University of Edinburgh.

Meteorological Expedition to the British West Indies

Prof. P. A. Sheppard, of the Department of Meteorology, Imperial College of Science and Technology, London, has recently left the United Kingdom to lead a small meteorological expedition from his department to Anegada (lat. 18° N., long. 64° W.) in the British Virgin Islands, British West Indies. The expedition, in which the National Institute of Oceanography is collaborating, is planning to study for about a month the transfer of momentum, heat and water vapour from the ocean into the Trade Wind air, to relate these transfers with the vertical variation of mean wind speed and direction in the first kilometre or two of the atmosphere and with the pattern and structure of Trade Wind cloud, mainly cumulus. This expedition follows an earlier expedition to the Scilly Isles during January 1951. There, momentum transfer processes were studied in the variable westerlies of middle latitudes, and the results indicated that the classical concept of the terrestrial friction layer, a layer half a kilometre or so in thickness, in which turbulence and momentum transfer drop off to zero at the top of the layer, needed revision. The results could be interpreted on the assumption that the momentum transfer was maintained or even increased with height by means of turbulence of moderate scale which was found to exist in the air. Unlike the classical boundary layer beneath a uniform stream of air, the wind speed in the westerlies increases with height up to the level of the tropopause, not through friction at the underlying ocean surface but because of the temperature drop towards higher latitude. In the Trade Winds a similar temperature drop causes easterlies near the surface to give way to westerlies (anti-Trades) aloft. This difference between Trade Winds and westerlies is likely to lead to markedly different patterns of momentum transfer in the two fields, a difference which if substantiated must be important in the understanding of the general circulation of the atmosphere. Anegada is a small low-lying island in a Trade Wind area, and the expedition will use it as a fixed platform to observe the variation in wind from one five minutes to the next, that is, the moderate-scale turbulence, in the first kilometre or two of the Trade air, using balloons. Time-lapse photography of the clouds will also be undertaken. The Woods Hole Oceanographic Institution in Massachusetts will collaborate with the Imperial College expedition by using an aircraft to take observations of cloud structure in the same region at the same time.

Photoelectric Studies of the Night Sky Light

A paper by Masaaki Huruhata on "Photoelectric Studies of the Night Sky Light" has been published in *Tokyo Astronomical Observatory Reprints*, No. 89 (reprinted from the *Report of Ionosphere Research in Japan*, 6, No. 1; 1952), which describes the method of study of the horizontal drift of the night sky. The measured emission of the infra-red radiation between 8500 and 11000 A. was identified as due to the OH ion; this radiation is so strong that it can be easily measured over the whole sky without suffering from the effects of bright star-light. The instrument consists of a photoelectric photometer furnished with a cæsium cell, the current being amplified by the electrometer tube. An infra-red filter placed in front of the photocell cuts out the visual light shorter than 8500 A. Observations were carried out at Yawatano, Skizuoka-ken, and the results are plotted for each hour for various periods between January 1, 1949, and December 11, 1950. On most nights the drift of intense or weak clouds of the night sky could be recognized, the direction of drift being mostly from north-north-east to south-south-west or in the opposite direction, and this direction is perpendicular to the geomagnetic parallel. On December 23, 1949, the velocity of the drift was estimated to be 1,000 km./hr., but this appears to be exceptional and several hundred km./hr. seems to be the normal speed. It is remarkable that the speed of the southward drift averages about 20 per cent more than that of the northward drift. Attempts were made to find some correlations between drift and the position of the moon, on the theory that wind in the upper regions of the atmosphere—about 300 km. high—might be caused by tidal movements, but none could be found, nor could any correlation be found between the drift and the ionospheric and geomagnetic disturbances observed in Japan proper.

Study of Forest Seeds in Sweden

An article by Einar Huss, entitled "Methods used in the Swedish Forest Research Institute in Seed Experiments", has been published in *Reports of the Forest Research Institute of Sweden* (*Meddelanden från Statens Skogsforskningsinstitut*, **40**, 53; 1952), in which it is stated that during the past few years, owing to the growing interest in forest culture in Sweden, a thoroughgoing study of questions touching the appropriate methods of treating forest seed and the characters determining the effect on plant results has been undertaken. There were also the problems of supplying the forest industry with enough seed, because of the greatly increased demand, and the necessity, owing to this increased demand, of producing the best possible quality of seed, which is a commercially expensive commodity. There are few

forestry departments in the world at the present day in which the demand for high-quality forest seed of many varying species does not exist, and, in the case of exotics, this often has to be imported. The objective of the study was to provide a "real average sample". At the beginning of the past decade, a new experimental selection method was introduced by Prof. Lars Tirén, director of the State Forest Research Institute's Forest Department, in the seed experiments of the Institute, which was described in 1948 in an essay published in the Institute's *Proceedings* (37, No. 5). Einar Huss's paper reviews the manner of treating cones and seed from Scots pine and Norway spruce. In eight short sections he deals with definitions and quantitative units, collection of cones, storage, selection, extraction of seed, de-winging and cleaning, sampling and germination. The ninth section treats of storage and the methods in use. The whole article merits close study by all foresters having to deal with this important seed problem.

Pea Embryos in Sterile Culture

An interesting contribution to our knowledge of the hormonization of seeds by growing dissected-out pea embryos in sterile culture has recently been made by W. Kruyt (*Proc. Koninkl. Nederlandse Akad. van Wetensch.*, Ser. C., LV, 4, 503; 1952). The peas were sterilized externally and the embryos removed with or without the attached cotyledons and grown in a sterile culture medium. Various pre-soaking treatments, for example, with and without growth-regulating substances, were investigated, and also the effects of factors in the culture medium and of leaving larger or smaller amounts of cotyledon attached to the growing embryo. It was found that the ratio of the amount of reserve material (in the cotyledons) to the size of the embryo has an important effect on development, that is, nutrition affects the morphogenetic development, the growth of root and sprout being stronger in proportion to the amount of cotyledon tissue left on the embryo. No development of leaves takes place in the dark, and, even in the light, embryos from which the cotyledons have been removed scarcely form leaves: leaf development, in fact, is in proportion to the amount of cotyledon left on the embryo. The author also reports the liquefaction of agar gels, especially by embryos with attached cotyledons. The development of lateral roots is mainly dependent on the amount of cotyledon tissue present. In a considerable series of experiments the action of various growth substances was also examined, the conclusion being reached that the greater part of the action of a growth substance, administered by pre-soaking the seeds, takes place by way of the cotyledons.

Life Insurance Medical Research Fund of Australia and New Zealand

The Life Offices' Association for Australasia has established the Life Insurance Medical Research Fund of Australia and New Zealand to promote and assist scientific and medical research. For the present it is intended to use the resources of the Fund to stimulate and support research in the field of cardio-vascular function and disease, and for this purpose the Fund is offering grants-in-aid and research fellowships. Grants-in-aid will be given to non-profit institutions with basic facilities and qualified personnel for medical research and will be used in support of specific programmes of research, both fundamental and clinical, under the direction of a particular investigator; the grants will be worth £1,000–3,000 a year (or more, in exceptional circumstances) for one to three years and are designed to cover all the financial requirements of a programme, except the salary of the head of the department or institute concerned. Research fellowships will be awarded to medical graduates, or those with equivalent scientific training, for full-time research, and will be divided into three categories: fellowships taken up in Australia and New Zealand, of £1,250–1,500 a year in value, which will be for one year (but renewable for further periods); travelling fellowships, of £1,500–2,000 a year in value plus travelling expenses, which will be for two years abroad, followed by a third year in an approved institution in Australia or New Zealand; and senior fellowships, which will be granted in special circumstances. Application forms (to be returned by March 31) and further information can be obtained from Dr. John H. Halliday, Medical Director, Life Insurance Medical Research Fund of Australia and New Zealand, 87 Pitt Street, Sydney, N.S.W.

Book Service for Industrial Operatives

The National Book League is seeking information regarding the availability and use made of works libraries, with the view of the eventual establishment of a consultative service to factories, as visualized in a report of its Books in Industry Committee in 1949. Factory managements or their libraries are being invited to supply details regarding the size of the technical library they maintain from their budgets, the number of general books thus maintained, and whether or not a works librarian is employed and the library regularly brought up to date and at what cost. Information regarding facilities invited from public libraries includes the accessibility of books to operatives and the extent to which the books are used. The service contemplated is for the man at the bench rather than for scientific or research staffs. Information should be sent to Mr. R. Lusty, chairman of the Books in Industry Committee, National Book League, 7 Albemarle Street, London, W.1.

British Agricultural History Society: Meeting in Reading

A new Society, to be known as the British Agricultural History Society, has recently been formed, and it is hoped that, besides the academic backing which it already enjoys, it will receive the support of a wide circle, including both farmers and townsmen, for whom the history of British rural life is of real interest. The first general meeting of the Society will be held in the University of Reading during April 13, and all who are interested are welcome to attend. The conference will open at 10.30 a.m. with the adoption of the constitution of the Society, which has been drafted by the provisional committee elected at the inaugural meeting last September, and with the election of officers. Following this formal business, Sir James Scott Watson will read a paper on "The Scope of Agricultural History". In the afternoon, Sir Frark Stenton will read a paper on "The Manor in English History". Visits to the Museum of English Rural Life, Reading, will be arranged during the day. The registration fee for the conference is 3*s*., and should be sent to the secretary of the Society, Mr. J. W. Y. Higgs, Keeper of the Museum of English Rural Life, Shinfield Road, Reading, Berks, from whom all further information can be obtained.

Eighth International Congress of the International Society for Cell Biology

THE date of the eighth international congress of the International Society for Cell Biology (Cytology Congress) has been changed from this year to 1954. It will be held in Leyden during September 1–7, under the presidency of Prof. E. Newton Harvey, of Princeton University, with Prof. P. J. Gaillard, of the Laboratory for Experimental Histology, University of Leyden, as secretary. Correspondence concerning the Congress should be addressed to Dr. W. H. K. Karstens, Botanical Laboratory, State University, Nonnensteeg 3, Leyden. Full members of the Society and candidates for membership approved by the International Committee are automatically entitled to attend the Congress, and to introduce two guests. Non-members are admitted as space permits, after provision has been made for members and their guests. Any member of the Society may nominate a new member from "those who have made outstanding contributions to cell biology over a period of years". The nominations, with a statement of qualifications and a list of the nominee's publications, should be sent to the secretary of the Society, Prof. J. F. Danielli, Zoology Department, King's College, London, W.C.2.

Endeavour Prizes for Science Essays

IN order to stimulate younger scientific workers to take an interest in the work of the British Association for the Advancement of Science and to raise the literary standard of scientific writing, Imperial Chemical Industries, Ltd., publishers of *Endeavour*, are offering a number of prizes for an essay, not exceeding four thousand words, on one of the following subjects: radio-astronomy; colour and chemistry; biology in world affairs; science and safety in transport; science and art; scientific contributions to medicine; scientific societies and their role; and power and civilization. Competitors must be less than twenty-five years of age and must send in their essays by June 1. The prizes will be 50, 25 and 15 guineas, respectively, with two special awards of 5 guineas for competitors less than eighteen, and in addition prize-winners will have their expenses paid for attendance at the British Association meeting to be held in Liverpool during September 2–9. Further details of these awards, which are known as *Endeavour* prizes, can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

University of Leeds

DONATIONS have been made to the University of Leeds as follows: £2,500 from the Cement and Concrete Association to the Department of Civil Engineering towards the cost of a universal testing machine; £1,100 from Bolton Leathers, Ltd., to the Department of Leather Industries, for the Boltonia Fellowship for 1952–53 and 1953–54; a gravity-feed stoker, valued at £1,085, from Crosthwaite Furnaces, and Scriven Machine Tools, Ltd., Leeds; and a grant of £500 a year (for one year in the first instance), with provision for superannuation purposes for half-time assistance and with up to £1,000 a year for expenses, from the Medical Research Council, to the Department of Experimental Pathology and Cancer Research, for work on the carcinogenic action of mineral oils.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: E. W. Momber (principal agricultural officer, Nigeria), assistant director of agriculture, Northern Region, Nigeria; B. E. V. Parham (senior agricultural officer, Fiji), deputy director of agriculture, Fiji; A. M. Anderson (fisheries officer, North Borneo), fisheries officer, Uganda; M. P. Benjamin (assistant agricultural superintendent, British Guiana), agricultural officer, Jamaica; J. O. Jaine (land ranger, Tanganyika), senior land ranger, Tanganyika; I. G. Lumsden (assistant conservator of forests, Northern Rhodesia), assistant conservator of forests, Nigeria; G. H. Rulf (assistant director of grain storage, Tanganyika), director of grain storage, Tanganyika; G. G. Rushby (senior game ranger, Tanganyika), deputy game warden, Tanganyika; E. H. Jones, agricultural officer (economist), Uganda; C. A. Waldron, agricultural officer, Tanganyika; H. I. Williams, bacteriologist, Federation of Malaya; A. Rogerson, scientific officer, East Africa High Commission; D. Bates, agricultural survey (cocoa) officer, Gold Coast; J. Forsyth, entomologist, Gold Coast; I. A. S. Gibson, mycologist, Forestry Department, Kenya; I. A. Hoffe, veterinary officer, Federation of Malaya; G. S. Scott, provincial tsetse officer, Tanganyika; W. E. Webb, senior scientific officer, forest entomologist, Timber Pest Research Unit, Gold Coast; T. W. W. Wood, assistant conservator of forests, Sarawak.

Announcements

Two Ramsay Memorial Fellowships, worth £400 a year plus a grant for expenses not exceeding £100 a year, are being offered for chemical research; they will normally be tenable for two years. One of the Fellowships will be limited to candidates educated in Glasgow. Further information can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1, to whom application forms must be sent not later than April 17.

THE Ministry of Education is arranging a short course in chemistry for teachers from technical colleges, to be held in the Municipal Technical College, Coventry, during July 15–24. The instruction will deal with modern chemical techniques relating to chromatography and to semi-micro-analysis, and will consist of lectures and practical laboratory work. The course will be residential, but local teachers may be accepted as day students; the total charge for board and lodging is £8. Further information can be obtained from the Ministry of Education (Teachers Short Courses), 36–38 Berkeley Square, London, W.1.

THE British Columbia Research Council at the University of British Columbia, Vancouver, has announced the following new appointments: *Chemistry Division:* H. Friedeberg (formerly of the University of Birmingham), W. F. Gruber (University of Vienna), H. G. Khorana (University of Cambridge), J. F. Smith (Imperial College of Science and Technology, London) and J. D. H. Strickland (formerly with the Ministry of Supply in Great Britain); *Metallurgy Division:* I. D. G. Berwick (University of Cambridge), J. G. Parr (University of Liverpool) and J. E. Srawley (formerly with the British Cast Iron Research Association).

SOME SOCIAL AND PSYCHOLOGICAL PROBLEMS OF AGEING

THE programme of the British Association meeting last year in Belfast included a session by Section J (Psychology) on the problems of ageing. Mrs. M. Gilmore was in the chair. In the opening paper, which was a review of the problems of ageing in relation to medical science, read by Dr. G. F. Adams, physician to the Geriatric Department of the City Hospital, Belfast, the reasons were considered why old age should present problems in modern times any more than in the past. There has been a progressive increase, both absolute and relative, in the proportion of old people in the population, this increase being the result of the decline in infant and young adult mortality produced by the medical and social advances that have been made possible by the application of the scientific method during the past century. As a result of this, more old people must be supported by a diminished proportion of wage earners. There is a corresponding increase in the numbers of elderly invalids to be cared for, who are suffering from the degenerative diseases of old age which medical treatment may ameliorate, but not cure. Meanwhile, the expense of medical treatment, especially hospital treatment, has risen enormously and continues to rise, and it has been suggested that the community is faced with a gloomy prospect of unlimited 'medicated survival' to be met by diminishing resources. Dr. Adams disagreed with this view. Pointing out that medicine has long evaded its responsibilities to the clinical and social medicine of old age, being preoccupied in other fields of research, he outlined the new approach being made to the medical care of the elderly through the clinical work of hospital geriatric departments and the influence of social medicine in surveys of the problems of ageing. Much success has already been achieved in the prevention of unnecessary invalidism among the elderly sick, and many elderly patients hitherto regarded as 'chronic invalids' have been restored to activity, reducing the burden of nursing and domestic care otherwise necessary for them. Dr. Adams concluded that estimates of future needs for the elderly sick should be based on the results of such work rather than on limits set by the out-dated system of social and medical care of the past.

The second paper was read by Miss S. R. Burstein, of the Wellcome Historical Medical Museum, who urged that the problems of many old people are essentially mental rather than matters of physical infirmity or disease. The problems of adolescence have been the subject of a great deal of careful psychological and social research; there is a need for similar research upon the emotional problems concerned with the transition from middle to old age and especially upon the ways in which the years of old age can be used. It should be recognized that old age is not something which comes suddenly—ageing is continuous from birth—and that it is fundamentally wrong to segregate old people as 'problem cases' away from the functioning life of the community.

Miss Burstein stressed that one of the difficulties for those doing research upon problems of old age is that they are usually younger, and that it is thus difficult for them to understand fully the outlook of the people with whom their research is concerned. She urged that discussion with old people individually or in small groups, if done with patience and respect, yields far more insight into their attitudes and needs than can methods such as questionnaire studies which are more immediately convenient to the research worker.

The traditional pattern in which the whole family, old and young, lived together under one roof has largely broken down, with the result that many old people are extremely lonely. A return to the traditional pattern is clearly impossible, and, even if it were, it might involve satisfying the needs of old people at an undue cost in terms of freedom and privacy for those younger. Intermediate solutions where, for example, old people live alone but close to younger relatives often work well. The point needs to be stressed, said Miss Burstein, that old people themselves must carry a large share of the responsibility for making such arrangements successful. Although they are often glad of the opportunity of leisure afforded by retirement, many of them are capable of useful work, and this applies not only to work at a job but also to help in the family as a functioning group.

Mrs. A. V. Hill, a member of the Advisory Council of the National Corporation for the Care of Old People, read the third paper, which was an account of some emotional changes observed in advanced old age—mainly between eighty and a hundred years. Although these emotional changes may accompany physical changes, the emotional needs of old people cannot be met by physical care alone. Little study has been made of old people's needs, and physical care without attention to emotional needs often constitutes actual cruelty. While certain main lines of emotional change can be observed, it should be emphasized that, on one hand, striking exceptions occur among very old people and that, on the other, changes can take place before any great old age in terms of years alone has been attained.

The behaviour of very old people can often be explained in terms of fear of death, or of illness or of change of environment. The will to live is as strong as ever, and fear of illness or accident may dominate the life of an old person. At the same time they may unconsciously feign illness in order to gain attention. Movement from one dwelling to another frequently produces a 'transference shock' with signs of mental and physical deterioration which can sometimes result in death. Usually, however, old people settle down in the new dwelling, although they may take some weeks to do so. This has been frequently noticed among new residents in old people's homes, and, when it seems likely to occur, the old people are persuaded not to cut adrift completely from their old haunts until they have come to know the new. Among other emotional attitudes, affection, friendship and concern for the opinions of others suffer a marked reduction. In the extreme, apathy and general indifference may appear, especially after long periods in bed. Interest

in what immediately concerns oneself may increase : thus small treasures are hoarded, and interest in food may grow. At the same time, the gift of being able to "enjoy other people" often continues to the end of a very long life.

Mrs. Hill urged that, broadly speaking, bed is bad for old people unless absolutely necessary on account of severe illness or weakness. Where possible, old people should be provided with small convenient dwellings where they can live alone. The independence and the effort involved in living alone can, as an example in one housing trust has shown, help old people to remain young for their age. Old people's clubs can help to relieve any loneliness which may be involved, and so also can part-time employment. An important experiment in the employment of people between seventy and eighty years of age for two hours daily is being made in Finsbury.

It is to be emphasized that people do not "suffer from old age" : they suffer from illness, unhappiness and loneliness, but not from old age as such. There seems to be an increasing tendency to resist and resent old age. Those old people who accept and understand its inevitability are emotionally in a much stronger position than others.

Dr. John A. Oliver, principal officer in the Ministry of Health and Local Government, Northern Ireland, read an address entitled "Thinking About Old Age", in which he gave an account of present-day social problems of the elderly, with some reflexions on social thought and social policy. He outlined the main features of the social problems of old age to-day—more people surviving into old age in a community distressed by a housing shortage and a dearth of domestic help ; and a weakening sense of family responsibility towards their elderly relatives on the part of parents anxious to give their children the best possible chance in difficult circumstances. This decline in family responsibility is encouraged, perhaps, by the lack of any legal obligation to provide for elderly relatives and by the increasing State provision being made for them. Dr. Oliver considered that the progress in social work and social legislation made in the last ten years has been largely pragmatic and has been "achieved without any real preparation in fundamental thinking". The practical workers beset by immediate problems have tackled them empirically as they arose, and our new social legislation, as it applies to the problems of ageing, has been launched in a philosophical vacuum. A philosophy of the social work, the social policy and the social services which we are operating must be evolved from experience and thought. Both legal and moral duties are involved in family responsibility for the aged, and we must recognize the fact that the State cannot be committed to an unlimited liability for the care of old people. Moreover, the hopes and desires of the old people themselves must be considered ; and, since home is the normal place for most of them to live and end their days in, social services designed to make it easier to look after elderly relatives at home should be augmented and their potential contribution to industry encouraged by suitable work under suitable conditions. Is progress henceforward to depend on individual enterprise, asked Dr. Oliver—"the effort of the old person, the effort of the relatives and the neighbours or on community services devised by the State" ? He said that he believes that this choice between individualism and collectivism is the central philosophical problem in the so-called Welfare State. In conclusion, he suggested that the British Association might establish a new section devoted to social science, or social philosophy, so that "British science may demonstrate its concern for social well-being and spiritual values".

Mr. A. T. Welford, director of the Nuffield Research Unit into Problems of Ageing, spoke of changes of human performance with age which affect capacity for industrial work. He stressed that many such changes associated with old age begin early in middle age, so that problems of employment for older people are not concerned only with those over the normal retiring-age. At some jobs ability seems to be well maintained into old age, and for almost all jobs a few older people can be found who are able to put up a performance comparable with that of a young man. At other jobs difficulties of maintaining adequate performance appear as early as the late forties. Difficulties of taking up a new job may appear earlier still.

The main difficulties for older people appear to be of three types, the first being where the form or the pace of the action involved is rigidly determined so that any slowness leads to an error of omission which cannot be afterwards redeemed. When the task is more flexible and the speed under the operator's control, an older person is often capable of compensating for slowness by increased care and accuracy. As a result of these compensatory tendencies, difficulties for people in later middle age in industrial work may go undetected—people maintain performance under an increasing strain until a suitable opportunity occurs to move away. Such moves are sometimes made following an illness which would not in itself warrant a change of job. Detailed examination of performance shows that often, contrary to popular opinion, slowness even in a manipulative task is due not to any limit set by the sense organs or by the effectors, but by the central brain processes which integrate and interpret information and form action.

The second type of difficulty occurs where the task is in some way complicated or confusing. So long as the relation between signals and the action required in response to them is simple and straightforward, performance by older people differs relatively little from that of younger. When, however, the relation is indirect or where several pieces of information have to be put together before action is taken, many older people are at a severe disadvantage.

The third type of difficulty is that of learning new tasks. This is, of course, generally recognized. The nature of the difficulty is not, however, clear. To some extent it is due to the application to the new task of previous habits which are not appropriate. In some cases, however, it appears to be due to inability to modify an erroneous method built up during early stages of practice.

In studying changes of performance with age, concluded Mr. Welford, it is important that we should not be led astray either by generalizations or by particular exceptional individuals. The ability of older people to do a job will depend both on the detailed demands of the job and upon the particular abilities which each individual can bring to it. Rigid general policies about retirement cannot therefore be justified on grounds of ability. The appropriate retirement-age will differ for the majority from one job to another, and from one individual to another at any job.

G. F. Adams
A. T. Welford

CARNEGIE INSTITUTION OF WASHINGTON

ANNUAL REPORT FOR 1951–52

THE report of the president of the Carnegie Institution of Washington, Dr. Vannevar Bush, for the year ending June 30, 1952*, reviews the progress of the Institution during the fifty years since its foundation and then briefly summarizes the research activities of the past year. The aim prescribed for the Institution was to "encourage, in the broadest and most liberal manner, investigation, research and discovery, and the application of knowledge to the improvement of mankind". In furtherance of this aim, the Institution has always devoted its main resources to fundamental research, which Dr. Bush distinguishes from applied research in terms of purpose rather than of method, and it has no thought of changing its policy. While he welcomes the growing realization in the United States that basic and applied science are two parts of one endeavour, and the consequent expansion of fundamental research with increased support from the Government, Dr. Bush believes that the Institution's primary responsibility remains to carry on fundamental scientific research with no initial view to its industrial application. Where, however, in its fundamental research, ideas and principles emerge that promise material advantage to society, it is proper for the Institution to explore some of the broader possibilities of application for human betterment.

In the main, the Institution has fulfilled its duty, in Dr. Bush's view, if it is diligent in making the results of its work generally known as promptly as possible. This preoccupation with fundamental research has simplified many of the Institution's problems and its relations with other bodies, as it has determined the policy in regard to patentable inventions which Dr. Bush outlines in some detail. He does not consider, however, that the absence in the United States of any effective organization for bringing the fruits of disinterested research to the point where they invite industrial development warrants the Institution plunging into the application of science. The Institution may sometimes, nevertheless, need to look ahead beyond its immediate programme of research and publication.

Dr. Bush justifies this policy by citing the part which the Institution has played, in collaboration with the National Research Corporation and the Stamford Research Institution, in exploring the practical aspects of the mass cultivation of algæ following the investigations on photosynthesis in its Department of Plant Biology which demonstrated the possibility of growing the green alga *Chlorella* so as to produce 56 per cent dry weight of protein. Other instances are also cited in the report of researches which have been conducted by the Institution during the past half-century so as to contribute to an understanding of the cosmos, the earth and its inhabitants, and which have later provided the basis of important developments or practical undertakings. They include early work in 1925 on pulsations and their echoes from the ionosphere, which was one of the pioneer researches in radar, investigations in the Geophysical Laboratory on low-expansion quartz glass, which led to the development of 'Pyrex' and similar glasses, and the basic study of the soda-lime–silica system in the same Laboratory, which contributed to a scientific understanding of the glass industry. Later, a modified formula for annealing 'Pyrex' glass in large castings was fundamental to the successful manufacture of the 200-in. 'Pyrex' mirror for the Hale telescope, and the Laboratory studies of the ternary system lime–alumina–silica contributed to the development of the Portland cement industry. The researches of the Department of Embryology form an important part in every text-book on human embryology published during the past decade, and the Soil Conservation Service of the United States Department of Agriculture has drawn extensively on the basic knowledge of the evolution of new plant species gained in the range-grass experiments of the Department of Plant Biology during the past decade.

Turning to current research activities, the report refers to the co-operation between, on one hand, W. Baade and R. L. Minkowski, of the Mount Wilson and Palomar Observatories, and, on the other, groups of radio observers in Australia and England which has led to the identification of the strongest radio source, Cassiopœia *A*, with a galactic emission nebula about five minutes of arc in diameter, and of the second strongest source, Cygnus *A*, with an extra-galactic nebula the structural pattern of which Baade interprets as probably representing two nebulæ in collision. A twelfth satellite of Jupiter was discovered by S. B. Nicholson on September 28, 1951. Investigations by E. H. Vertine, of the Department of Terrestrial Magnetism, afford an explanation of the major changes in the rate of the earth's rotation during the past fifty years, while, under a joint project with the Geophysical Laboratory, methods have been worked out for measuring the ages of virgin granite and of unaltered rocks found in close association with such massive igneous monoliths as, for example, the Sierra Nevada range. New methods and apparatus developed by the latter Laboratory have permitted rapid and easy measurements at pressures up to four thousand atmospheres and concomitant temperatures up to 800° C.

The Department of Plant Biology has continued its studies of the alga *Chlorella*, including the rate of photosynthesis with intermittent light over new ranges of intensities and flashing schedules, while urea has been found to be an excellent source of nitrogen for the growth of algæ. Some four hundred new hybrids have been produced between different species of blue grass, and a basic study of the genetic and ecological systems that characterize natural races and species is being advanced using the milfoils or yarrows. In the Department of Genetics investigations on mutability in *Escherichia coli* indicate that the rate of spontaneous mutation varies with temperature according to the van t'Hoff rule, and that an intimate relation exists between spontaneous mutation and cell division. It has been established that a typical bacterial virus consists of a membrane (chiefly protein) containing almost pure nucleic acid and that the function of the viral membrane in the infection of the bacterial cell begins with the anchoring of the viral particle to the cell wall and quickly ends with the injection of the viral nucleic acid into the cell. An enzyme capable of breaking down isolated, but not intact, intracellular deoxyribonucleic acid has been discovered in onion root tips, and studies on maize have indicated that at least two classes of functional genetic unit are carried by the chromo-

* Report of the President of the Carnegie Institution of Washington for the Year ending June 30, 1952. By Dr. Vannevar Bush. Pp. 20. (Washington, D.C.: Carnegie Institution, 1952.)

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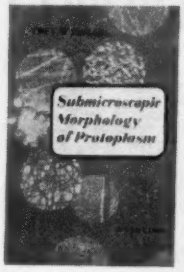

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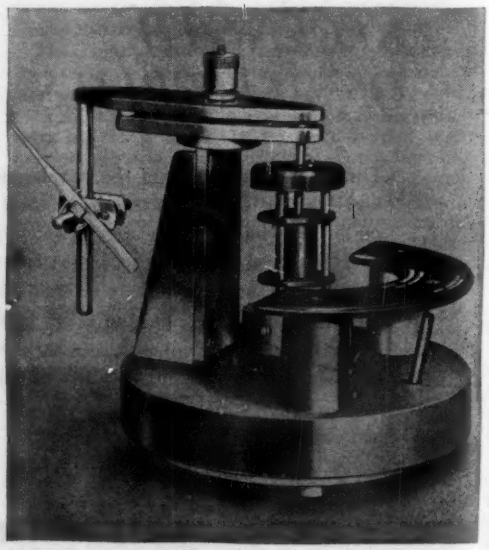

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